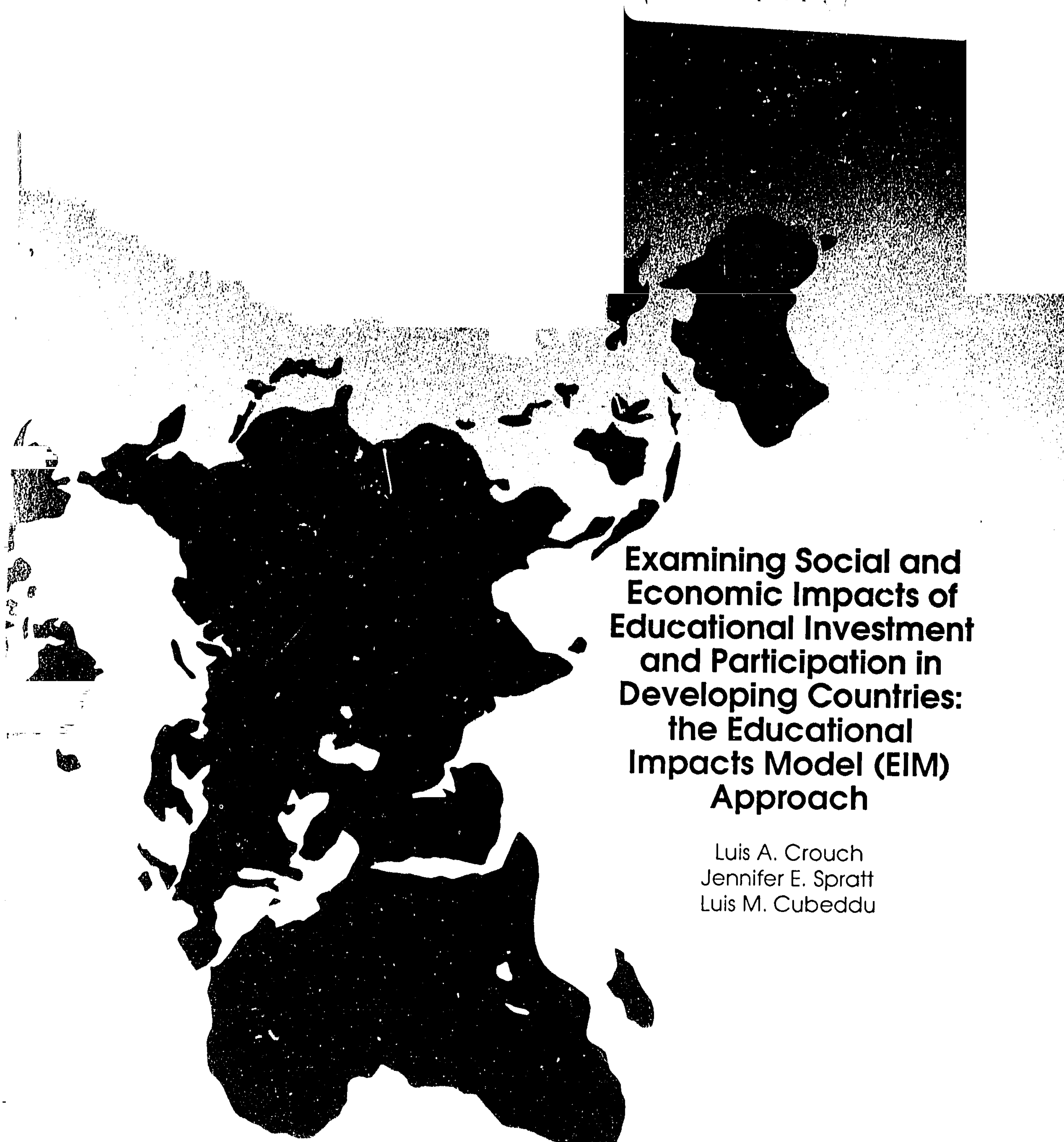


Examining Social and Economic Impacts of Educational Investment and Participation in Developing Countries: the Educational Impacts Model (EIM) Approach

Luis A. Crouch
Jennifer E. Spratt
Luis M. Cubeddu

B • R • I • D • G • E • S
Basic Research and Implementation in DevelopinG Education Systems

The Basic Research and Implementation in DevelopinG Education Systems Project (BRIDGES) is directed by the Harvard Institute for International Development and the Harvard Graduate School of Education, under Cooperative Agreement No. DDP-5824-A-5076 with the Office of Education, Bureau for Science and Technology, United States Agency for International Development. Also participating in the Project are the Institute for International Research, Michigan State University, the Research Triangle Institute, and Texas Southern University.

The BRIDGES Group includes educators, researchers, planners and policymakers committed to improving opportunity and quality in Third World schools. The goal of their collaborative effort is to identify policy options that will increase children's access to schooling reduce the frequency of early school leaving and repetition, improve the amount and quality of what is learned, and optimize the use of fiscal and educational resources.

The *BRIDGES Research Report Series* is edited by the Harvard Institute for International Development. The *Series* is a collection of reviews of the state-of-the-art in research, and original research reports on basic education in developing countries. Each review summarizes research about a particular policy issue and suggests policy options. Original reports on BRIDGES-sponsored research present new information about the impact and costs of specific alternatives that the reviews have identified as most promising.

Examining Social and Economic Impacts of Educational Investment and Participation in Developing Countries: the Educational Impacts Model (EIM) Approach

Luis A. Crouch
Jennifer E. Spratt
Luis M. Cubeddu

Research Triangle Institute
Research Triangle Park
North Carolina
USA

Acknowledgements
This study benefitted greatly from the intellectual support and in-depth critique of Scott Moreland, who inspired and collaborated in the early conceptualization of the model; Noel McGinn, without whose encouragement this work would not have been possible; the perceptive and thorough comments of two anonymous referees; and the excellent support and gentle prodding of the BRIDGES editorial staff led by Billie Jo Joy. Please address inquiries to the authors, Center for International Development, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709-2194, USA.

Foreword

There is no lack of evidence of the critical importance of education for economic growth. Following Schultz' (1963) pioneering work calculating net benefits to education, there have been a host of studies that demonstrate that investment in education has high public and private returns (Psacharopoulos, 1985). In many cases, the rate of return to education is higher than that for investment in physical capital and infrastructure.

This fact was obscured during the 1980s. International banks and development agencies encouraged developing countries to increase exports. Many of these countries borrowed heavily, in part to finance efforts to increase exports. When terms of trade worsened, countries with heavy debt burdens were encouraged to reduce public sector spending. Education was a major casualty (Reimers, 1991).

Education budgets were slashed despite evidence and arguments that investment in education was the best long-term guarantee of economic recovery. These arguments are restated in The Economist (1992) and the World Bank's World Development Report 1991. Expansion and improvement of education contribute to economic growth in several ways. Education provides:

- the knowledge base for technological innovation, an engine of growth;
- the skills and values required for a productive labor force; and
- an efficient mechanism for a more equitable distribution of income required for strong domestic markets as well as social justice.

Education makes its greatest contribution to development not when it is reserved for a privileged few, but when it is widely and equitably distributed. In countries that have not yet achieved universal completion of high quality basic education, investments in basic education have higher rates of return than do investments in higher education.

There is nothing new about this argument. The empirical basis to sustain these assertions has been available for at least two decades. Why then should we expect any change in how governments allocate resources?

A major objective of the BRIDGES Project has been to increase the use of research-based information for policy options affecting education. Among other activities, the Project has examined the process of how decisions are made about allocating educational resources.

The level of public spending on education is specified in government budgets that are often set in medium-term plans and adjusted annually. Plans and budgets result from negotiations between representatives (generally ministers) of the various sectors included in the president's (or prime minister's) cabinet. In many countries a minister of finance plays a critical role in making decisions about total budget allocations.

This process relies heavily on the use of technical information, but that information is organized by each of the sectors to support its objectives. When Finance is the most powerful actor, the arguments that receive most attention are those with economic rationale and data. Ministries of education most often lack the capacity to present arguments which are buttressed by economic logic or data. In a room full of lions, education too often is a lamb.

When Finance is the most powerful actor, the arguments that receive most attention are those with economic rationale and data.

United Nations/B. Wolff

The Educational Impacts Model (EIM) is designed as a tool to support efforts of ministers of education to increase allocations to the education sector. Other research and software packages in the BRIDGES collection are designed to stimulate discussion on the allocation of resources to different options in education. This package examines the larger question—is spending on education important for development?

An instrument of this kind is not easy to design. On the one hand, it must be transparent enough that a non-technical user — for example a minister of education with no training in economics — can understand how to use it. On the other hand, it must be technically sophisticated and complex enough to persuade economic decision makers of its validity.

The EIM is intended as an instrument to promote discussion, rather than to provide precise answers. It is a general model based on data from a number of countries. The outcomes it generates will not, therefore, necessarily fit any given situation. The EIM includes only a few of the many factors involved in education: it focuses primarily on population growth and economic productivity.

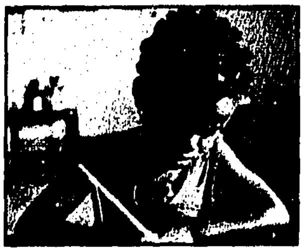
The EIM is based on empirical data from 80 countries. The research on which the model is based generated results that have been compared with other published research, including other BRIDGES research. Some of these findings deserve special mention.

- Enrollments in education grow principally as a result of increased supply.
- Rates of completion increase with increased spending per student.
- Education of women lowers fertility rates and infant mortality rates, and eventually contributes to declines in population growth rates.
- Education of women delays age of marriage and contributes to increased female participation in the labor force.
- Participation rates have an indirect effect on growth of GNP, and GNP per capita.

As noted, the empirical evidence to support these assertions has been available from other sources. It is our hope that the use of the EIM will increase the effectiveness of ministers of education in budget negotiations. We hope also that the EIM will provide students of education and development with a means to study the complex relationships that make education an essential part of the development process.

Noel F. McGinn
March 21, 1992

Table of Contents



Executive Summary

The decades of the 1960s and 1970s saw a tremendous expansion in school enrollment in the developing world. In the poorest countries, primary enrollment itself grew at least 150%. At the secondary level, enrollment rates tripled, and enrollment itself quintupled. Education budgets also expanded, though not as a share of national budgets.

Yet, in spite of this phenomenal expansion, as of the late 1980s nearly half of the developing world still had primary enrollment rates below 100%. A third of the countries had rates below 75%, and roughly a dozen countries enrolled less than half their children. By the late 1980s, expansion had either slowed down or essentially ceased, and, in the countries with lowest enrollment, some of the earlier progress had actually been reversed. Furthermore, in most countries, including those which successfully enrolled the majority of their children, quality remained very poor. Even in the face of these alarming gaps in quantity and quality, the level of effort devoted to education, as measured by budgetary allocations, has decreased in the most cases, and in the remaining cases has remained roughly constant.

United Nations/L. Gubb

Our research shows that education is the most profitable form of social investment available.

Key policy questions are raised by the juxtaposition of, on the one hand, tremendous expansion, and on the other, the reality that many children are not in school and quality overall remains chronically poor. Did the expansion of the 1960s and 1970s result in increased welfare and productivity? What justification (apart from entitlement-based arguments) is there for continued effort? This report contributes to answering these significant questions and provides support to those who would advocate increasing public and private resources for education. Other reports and studies have come to similar conclusions based on microeconomic and case study analysis; our report looks at the same issues from a macroeconomic, gender-specific, and multi-sectorial perspective, using a unified, global data set.

At the most general level, the conclusions of the report can be summarized in two sentences:

- Budgetary allocations really do matter, and

- Educational participation, in turn, has a sharp and unequivocal (delayed) effect, unequaled in some cases by any other form of measured socioeconomic intervention, on a host of socioeconomic indicators that are key to social welfare and economic development. The clear policy implication is that budgetary allocations to education have to be maintained or even increased, even as unit costs are contained and other improvements in management practice (such as decentralization) and financing (such as mobilizing more private sources) are implemented.

Specifically, the study concludes that:

- Every percentage point increase in the share of GDP (Gross Domestic Product) allocated to primary education is associated with an increase of slightly less than 20 percentage points. This is offset by increases in cost, since every percentage point increase in unit cost (as a proportion of per capita income) is associated with a 3 percentage point decline in enrollment rates. Other influences (such as per capita income, "culture" as proxied by world region, degree of urbanization, etc.) on enrollment rates are rather weak in comparison with increases in the educational share of GDP and the unit costs of education. The influence of budgetary and cost factors is the same for boys and girls, although other factors result in lower enrollment of girls for any given level of budgetary support and unit costs.

It is also important to note that here, as in all cases below, the estimates are made for poorer countries. The gains we describe hold for low income, low educational participation countries, since it is likely that there are decreasing returns to education.

- If accompanied by a strong family planning program, every 20 percentage point increase in female enrollment is associated with a decrease in fertility of 0.5 children. The maximum strength of the effect, however, takes some twenty years. Stated another way, if female enrollment was low twenty years ago (for example 20% enrollment), a doubling of family planning effort from the average in the 1980s, would lead to a decrease in fertility of only 0.25 children. If female enrollment was high 20 years ago (80% enrollment), the same doubling of effort in family planning programs is several hundred percent higher. High male enrollment has little measurable effect separate from high female enrollment.

- Female education was the strongest predictor of lower infant mortality. Every 20 percentage point increase in the secondary female enrollment rate is associated with a drop in infant mortality of some 30 children per 1,000. Again, male education had little measurable effect apart from female education. No other socioeconomic variable, such as potable water, level of urbanization, or income per capita was found to have as a strong effect as female education. As with fertility, the maximum measurable effect of female education on infant mortality requires a lag of at least twenty years. The effect is likely to weaken as education is universalized.

- Partly via its effect on infant mortality, and partly in a direct fashion, educational participation is strongly associated with improvements in life expectancy. Via the infant mortality effect, which is the main cause of increased life expectancy in developing countries, a 20 percentage point increase in secondary female enrollment is associated with a 6-year increase in life expectancy. A direct effect is weaker, but still noticeable and statistically significant: a 20 percentage point increase in total enrollment is directly associated with an increase in life expectancy of between 1 and 2 years. The effect is also delayed by about twenty years.

- In the absence of strong family planning programs, increased educational participation (either by itself or in combination with increased overall investment and economic growth) cannot be counted on to slow population growth.

- Female educational participation also has important impacts on other socioeconomic variables, such as age of marriage and labor force participation, but these effects are weaker than those discussed previously.

- Budgetary allocations to education (as a share of national income) affect economic productivity approximately as much as allocations to overall investment. Thus, holding the policy environment constant, and within the range we have estimated, educational "consumption" (which is how it is classified in the national accounts) is roughly equivalent to investment as traditionally defined and measured in the national accounts. However, the effect is considerably more delayed than the effect of more traditional forms of investment.

All of these results have been integrated into a computer simulation model that allows the user to see the implications of increased investment in education and reduced unit costs on all of the social and economic welfare indicators discussed above. This computer simulation model is available on diskette from the authors for examination and testing of hypotheses. Also available is the entire data set used to generate the model's equations. Thus, the user can test the results presented in this report and examine alternative ways of approaching these issues.

The availability of this information on diskette and on easy-to-use software is intended to lay bare the logic and mechanisms involved in generating these results. In this way, we encourage developing country researchers and educational advocates to use similar approaches to construct arguments based on their individual country data.

In summary, considering its highly significant impacts on social welfare and considering the equivalency of its effect on economic productivity to that of other forms of investment, educational policy advocates can continue to promote education not only as a basic right, but as a very profitable form of social investment. Our research shows that education is the most profitable form of social investment available. It is also fully competitive, in the long run, with traditional economic investment. This should not be seen, of course, as an excuse to push for increased budgetary allocations and expenditure without cost-consciousness. Experience in many countries has shown that excessively rapid and careless educational expansion, without first reforming management, policy, and internal allocation problems drives unit costs upward, does not produce the intended impacts on enrollment and quality, and can discredit educational expenditure as a form of investment. **Important educational management and policy reforms, and then increased allocations, should be the sequence.**

Section I: Introduction

Educational Investment and Development: Critical Policy Decisions

Education has been the highest social sector priority in most countries of the developing world for several decades, serving as a vehicle for economic, institutional, and individual development. But after nearly thirty years of significant educational expansion in many developing countries (see Figure 1), formal education has come under serious scrutiny. Analysts and observers have noted, for example, that growth in formal education has not always been followed by a more equitable distribution of income;[1] that the ranks of the educated unemployed have in some cases begun to surpass, in relative terms, those of the uneducated unemployed; that education has not ensured economic prosperity; that illiteracy continues to grow. In light of such observations, and especially under the burden of economic adjustment that has characterized the 1980s, governments and researchers alike have begun to reevaluate expenditures in education (Coombs, 1985).

Noel McGinn

Through the 1980s many countries have made little or no increase, and in some cases an alarming reduction, in educational expenditures as a proportion of total GNP.

Despite much progress in many countries, in the late 1980s there were still roughly a dozen low-income and middle-income countries[2] with primary school gross enrollment rates under 50%, and about 16 more countries with rates between 50% and 75%. Together, these countries represent about a third of the low- and middle-income countries reporting such data; another 20 or so countries have rates between 75% and 100%. In total, about half of the developing countries have gross primary enrollment rates under 100%. In these countries, as well as in many that have reached universal or nearly universal primary education, the quality of such education is generally very poor. Thus it can be argued that, in spite of the expansion of the last three decades, universal education of a basic, decent quality is an untried experiment in a large majority of developing countries. In this light, a reversal of the scant progress made thus far would be potentially disastrous.

Through the 1980s many countries have made little or no increase, and in some cases have alarmingly reduced educational expenditures as a proportion of total GNP (Table 1). Of 31 low- and middle-income countries for which educational expenditures information was available (Lockheed, Verspoor, et al. 1989; World Bank, 1991), the average change was a 4% reduction between 1980 and circa 1989. A total of 14 countries suffered substantial reductions (from 20% to 83%), 6 had more modest losses or remained relatively stable, and 11 increased spending levels substantially. In one-third of an additional 15 countries for which the most recent data is only through 1985, educational spending levels fell substantially (more than 15%) over the 1980-1985 period. Latin America as a region appears to be the hardest hit, with 11 out of 15 reporting countries reducing spending since 1980. Africa is second; for every African country reporting a substantial increase in spending levels since 1980 (Botswana, Ethiopia, Ghana, Malawi, Togo, and Zimbabwe), there is at least one showing an equivalent and, in some cases, drastic decline (Burkina Faso, Cameroon, Mali, Mauritius, Nigeria, Zaire, and Zambia).[3]

1. Indeed, some argue that education may even encourage the production or reproduction of inequitable class structures (Bourdieu & Passeron, 1977; Ram, 1989).
2. As categorized by World Bank definitions.
3. As a proportion of total expenditures and in absolute terms, of course, changes in government spending on education may show patterns different from these, due to concomitant fluctuations in total government spending as a percentage of GNP, and in GNP size. (See, for example, data reported by Ogbu and Gallagher (1991) for Botswana, Burkina Faso, Cameroon, and Ethiopia.) We prefer using educational share as a proportion of GNP because it reflects a country's theoretically "possible spending power" in a given year in a way that these other indicators do not.

Latin America as a region appears to be the hardest hit, with 11 out of 15 reporting countries reducing spending since 1980.

Table 1. Trends in Education Expenditures as Proportion of GNP, 1977-1989

	Education Expenditure as Proportion of GNP				Relative Change in Expenditure Level (% of previous period)		
COUNTRY	**1975**	**1980**	**1985**	**1989**	**89/80**	**80/75**	**WORLD REGION**
COUNTRIES WITH 1989 DATA							
Nigeria	0.017	0.047		0.008	17%	276%	AF
India	0.028	0.027	0.032	0.005	19%	96%	AS
Zaire	0.032	0.034		0.011	32%	106%	AF
Zambia	0.051	0.042	0.050	0.017	40%	82%	AF
Argentina	0.022	0.030	0.037	0.014	47%	136%	LA
El Salvador	0.031	0.037		0.018	49%	119%	LA
Peru	0.032	0.029	0.025	0.018	62%	91%	LA
Ecuador		0.052	0.035	0.033	63%		LA
Burkina Faso	0.023	0.025	0.024	0.016	64%	109%	AF
Costa Rica	0.065	0.071	0.043	0.047	66%	10[illegible]%	LA
Mali	0.035	0.036	0.036	0.026	72%	103%	AF
Chile	0.040	0.044	0.043	0.033	75%	110%	LA
Cameroon	0.039	0.033		0.025	76%	85%	AF
Mauritius	0.022	0.048	0.036	0.037	77%	218%	AF
Bolivia	0.035	0.042		0.034	81%	120%	LA
Mexico	0.023	0.028	0.022	0.026	93%	122%	LA
Uruguay		0.021	0.024	0.02	95%		LA
Morocco	0.033	0.051		0.049	96%	155%	ME
Rep. of Korea	0.016	0.032	0.038	0.031	97%	200%	AS
Kenya	0.060	0.063	0.062	0.062	98%	105%	AF
Thailand	0.025	0.028	0.033	0.029	104%	112%	AS
Syrian Arab Republic	0.023	0.024	0.034	0.028	117%	104%	ME
Tunisia	0.045	0.046	0.052	0.055	120%	102%	ME
Togo	0.035	0.053	0.059	0.065	123%	151%	AF
Panama	0.054	0.048	0.050	0.061	127%	89%	LA
Malawi	0.022	0.026	0.024	0.036	138%	118%	AF
Ethiopia	0.027	0.026	0.035	0.037	142%	96%	AF
Zimbabwe	0.033	0.064	0.076	0.095	148%	194%	AF
Turkey		0.023	0.02	0.037	161%		ME
Botswana	0.045	0.058	0.065	0.101	174%	129%	AF
Philippines	0.013	0.015	0.013	0.027	180%	115%	AS
Ghana	0.044	0.017	0.026	0.036	212%	39%	AF
AVERAGE CHANGE					96%	124%	
ADDITIONAL COUNTRIES (lacking 1989 data)					**85/80**	**80/75**	
Congo People Republic	0.068	0.064	0.047		73%	94%	AF
Jamaica	0.047	0.068	0.053		78%	145%	LA
Central Africa	0.042	0.037	0.029		78%	88%	AF
Lesotho	0.033	0.038	0.031		82%	115%	AF
Madagascar	0.030	0.046	0.038		83%	153%	AF
Burundi	0.022	0.026	0.024		92%	118%	AF
Dominican Republic	0.018	0.016	0.015		94%	89%	LA
Sudan	0.046	0.044	0.043		98%	96%	AF
Haiti	0.010	0.012	0.012		100%	120%	LA
Venezuela	0.041	0.040	0.048		120%	98%	LA
Pakistan	0.015	0.015	0.018		120%	100%	AS
Greece	0.019	0.022	0.028		127%	116%	ME
Mauritania	0.038	0.051	0.076		149%	134%	AF
Bangladesh	0.007	0.011	0.018		164%	157%	AS
Nicaragua	0.020	0.029	0.060		207%	145%	LA
AVERAGE CHANGE					111%	118%	

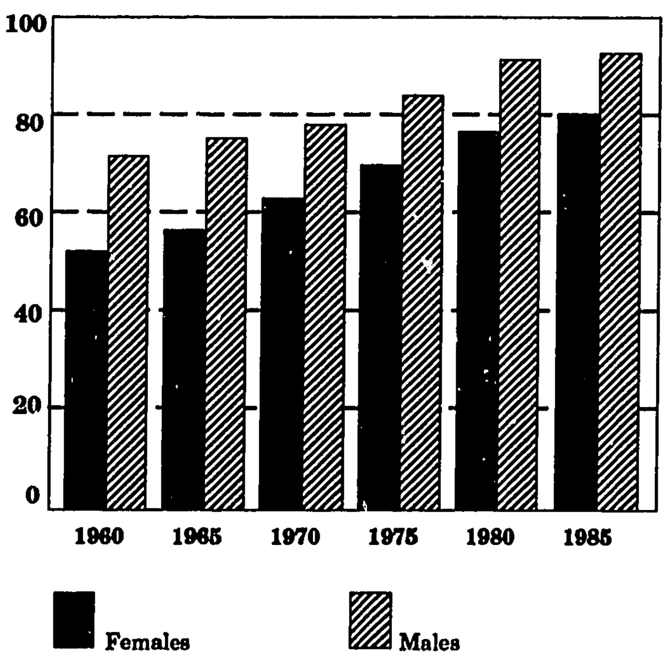
SOURCES: For figures through 1985: Lockheed & Verapoor, et al. (World Bank, 1989).
For 1989 figures: World Development Report (World Bank, 1991).

...the educational participation of girls has remained lower than that of boys in many countries, despite compelling evidence of an important role for females' education in the pursuit of many social and economic development goals.

Reimers (1991) has examined in depth the phenomenon of reductions in spending in Latin America, both in absolute terms and relative to spending in other sectors. His work demonstrates that in many Latin American and Caribbean countries, "...the education sector suffered disproportionately the adjustment burden and that the hopes of the seventies were dashed in the eighties." Further, Reimers notes, expenditure reductions were accompanied by changes in educational budget structures which strongly suggest a political priority shift away from education and, even more alarmingly, from lower levels of education.

In addition, the educational participation of girls has remained lower than that of boys in many countries, despite compelling evidence of an important role for females' education in the pursuit of many social and economic development goals. Figure 1 depicts the persistent gender differential in primary enrollments for 80 developing countries over a period of 25 years.

Figure 1: Gross Primary Enrollment Rates by Gender, 1960-1985*



*average for 80 developing countries

In short, during the 1990s there is a danger that many countries will face serious or continued reversals of earlier progress in educational investments while other countries will find themselves further away from embarking upon any serious educational expansion. In this period of difficult decisions about distributing limited resources, it is more important than ever that policymakers, planners, and researchers develop well-targeted, efficient educational policies and strategies. They must reevaluate the role of investing in educational participation as a way to achieve positive social and economic impacts. Ideally, they should examine carefully the gender-specific effects of education, long-term as well as short-term outcomes, and the social and economic conditions which enable education to have positive effects or prevent it from doing so.[4]

In pragmatic terms, educational policymakers must have effective ammunition to fight for the education sector during national planning and budget efforts. There is evidence that ministries of education often lack the political standing, as well as the basic information, to argue strongly for education in the face of other development sectors and interest groups (Reimers, 1991). To the extent that policy dialogue and decisions can be influenced and enhanced by the results of social science research, providing such ammunition in readily usable forms is a valuable contribution being made by the educational development research community in a number of ways. The work described here represents one approach to this endeavor.

4. As Simmons (1979) has reminded us, while education may be a key to development, "the development door" may well be "locked [from] the other side" (p. 1005) in the absence of conditions that enhance education's effects, such as a job market for mid- and higher-level manpower or a population policy that supports family planning techniques.

Section II: Assessing the Role of Education Through Simulation Models

In part as a response to diminishing political interest in education, a number of researchers and institutions have published extensively on the benefits of education. Macrolevel arguments in favor of educational investment have been cast in terms of the favorable effects of education on particular economic outcomes such as, income or productivity (e.g., the rate of return literature and studies on the impact of education on farmer productivity), or on key specific social indicators such as total fertility rates or infant mortality rates (see, for example, the eloquent arguments in the 1991 World Development Report).

Researchers have also pointed out for some time (Psacharopoulos & Woodhall, 1985), that the effects of education are truly multisectoral or intersectoral. The multisectoral nature of the impact of education is *implicitly* recognized, as shown by the many successful demonstrations of educational effects on a broad array of socioeconomic indicators. But there have been very few efforts to provide a truly integrated analysis of the intersectoral effects of education.

Furthermore, conclusions from many studies on the effects of education have concentrated on the size of the effect and ignored the implications of the time lags involved. Some of the arguments, while methodologically correct and defensible, focus on a single, dimensionless number (e.g., a rate of return), and thus obscure the importance of investment lag. As a strategy for defending educational investment, the excessive focus on single, timeless numbers can generate unrealistic expectations and may backfire in the long run.

Objectives for an Integrated Model of Educational Impacts

The shortcomings of conventional arguments for educational investment led to the development of the Educational Impacts Model (EIM) described here. The EIM was designed as a research base for policy dialogue in order to demonstrate with minimal data requirements the nature, time frame, and relative magnitude of intersectoral effects of educational investment and participation. It was also developed to provide material for generating serious dialogue with policymakers about the potential benefits of continued (or increased) investment in education. Thus, in spirit and intent, the EIM is in the tradition of rate of return and education impact studies.

The model can be used to develop "mechanicals" for policy dialogue. It generates graphical and numerical outputs and its results can be put into storyboards using computer graphics.

To produce a model that could be used to develop such policy dialogue tools, we imposed a number of requirements during the EIM development. The model

...educational policymakers must have effective ammunition to fight for the education sector during national planning and budget efforts.

United Nations/O. Monsen

had to be broadly comprehensive and analytically defensible, yet simple and parsimonious so that its message would be clear and to the point. It had to be honest about time lags by emphasizing that time mediates education's impact on society. The model had to be computable in order to be capable to incorporate specific policy scenarios and produce graphical output. To seriously address the issue of intersectoral effects, it had to capture, and compute, all of the known effects in a truly intersectoral, rather than a "serially multisectoral" fashion.[5] Held simultaneously, these requirements raise the level of complexity considerably; on the other hand, the requirement of simplicity and parsimony imposes discipline on both method and scope.

5. For example, the impacts of education on fertility and on infant mortality have to be integrated in order to estimate its overall impact on population. This last requirement imposes a serious restriction in the use of data: all the equations should ideally be estimated from a consistent data set, using, to the extent possible, common definitions across countries and across equations.

Methodologically, the EIM is largely unrelated to the tradition of formal education sector modeling. The main tradition in formal education sector models, starting in the early 1960s with the work of Bowles (1969), Adelman (1966), and others, has emphasized planning applications (by providing quantitative recommendations for specific levels of investment in sub-sectors within education), rather than broad policy dialogue or formulation. There has been little formal modeling of education, in an intersectoral context, aimed at influencing broad policymaking and resource allocation to education.

In this sense, the EIM belongs not to an education modeling tradition, but to the tradition of intersectoral economic or socioeconomic modeling. This latter tradition is exemplified by computable general equilibrium models associated with the World Bank (see Dervis, de Melo, & Robinson, 1982), or by computable long-range socioeconomic models associated with the International Labour Office (see Moreland, 1982; 1984) and with the World Bank (see Wheeler, 1984b for an example focusing on education). All of these models are based on equations which mathematically describe the relationships between the key variables contained in the model (e.g., education and fertility, fertility and population, population and income per capita). Taken together, a given model's equations characterize the socioeconomic system in question, emphasizing those aspects under consideration. Many of the equations include important variables that represent "policies" which are set by the government during investment or policy decisions, and are therefore held as assumptions within the model. By solving the equations (either simultaneously or recursively) for different levels of these policy assumptions, it is then possible to "trace out" the effect of these policy assumptions on all the other variables.

This style of intersectoral modeling, while not intended to provide precise prescriptions, has been very successful at focusing the attention of developing country policymakers and technocrats on the importance of certain types of policies and investments. As a result, it has helped them develop policy and investment priorities. Given that this is both the aim and method employed by the EIM, the model belongs in the socioeconomic "policy dialogue" tradition, rather than in the "planning" tradition of educational modeling. Examples of the kinds of simulations that can be run with the EIM for use in policymaking are given in Section V.

Section III: Overview of the Educational Impacts Model (EIM)

The Educational Impacts Model demonstrates long-term, interactive effects of education on development goals in the areas of population and health, labor force participation, and economic productivity. The model controls for other economic, social, and cultural determinants of these outcomes, and incorporates indirect as well as direct effects of education, feedback loops, and gender-specific effects.

The EIM permits the user to specify, for a given region or country, educational policy inputs that include the size of the overall education budget, the proportion of the budget allocated to primary education, and per student expenditures in primary education. The user may also manipulate the level of government support for family planning and the fixed public investment share. Once inputs are specified, the model simulates the effects such inputs would produce on educational participation rates and social and economic outcomes. The full database and integrated simulation model are available on diskette, in Lotus 1-2-3 (version 2.2) format.

The EIM Database

All estimation equations in the EIM are the result of empirical modeling efforts which employed national level time-series data available on 80 developing countries for the period 1960 to 1985. Countries currently classified as low and middle income by the World Bank were included, with the exception of nonreporting nonmembers, countries with a 1985 population under 1 million, and then-centrally-planned economies (Poland, Hungary, Yugoslavia, and Romania). Selected variables from the World Tables database were joined with additional information from subsequent publications of the World Bank, Unesco, and other sources (International Labour Office, 1985, 1987, 1988; Komenan, 1987; Lockheed & Verspoor, et al., 1989; Population Crisis Committee, 1987; Unesco Statistical Yearbook, 1986; United Nations, 1987; World Bank 1984, 1988a, 1988b, 1989) to produce the EIM database. Appendix 1 presents an alphabetical listing of the countries included in the database, and a selection of educational and other key development indicators for each country. Appendix 2 provides a listing and description of all variables in the database, including the source of data and years represented. Appendix 3 presents a summary list of all estimation equations on which the simulation engine is based.

Model Limitations

As with all cross-national aggregate-level modeling efforts, the EIM can only illustrate general effects. It must be understood that the analysis of aggregate data should not be used to infer specific relationships at levels more minute than the level of aggregation. Thus analysis based on nationally aggregated data, for example, cannot be interpreted to provide evidence of effects at the level of the family or the individual. But such results should be useful in identifying and illustrating the general nature of the interdependencies that exist between education and other sectors, and in directing policymakers' attention to these important intersectoral linkages.

...results should be useful in...directing policy attention to...important intersectoral linkages.


United Nations/S. Lwin

Data limitations have constrained the complexity of the modeling equations employed in the EIM. Data disaggregated by both gender and environment (urban or rural), or by gender and economic sector, were seldom routinely available for most countries in the database. Thus, precluding specific consideration of differential gender disparities by environment or sector in educational attainment, labor force participation, or productivity.

The lack of adequate and cross-nationally comparable indicators of educational quality, impeded an examination of the impacts of educational quality in the current EIM. Potentially useful quantitative indicators of educational quality include actual student time spent in the classroom or engaged in school activities, average class size, and direct measures of skill acquisition and other indicators of learning. It is unlikely, however, that such specific quality factors will become widely available for macroeconomic time-series analyses in the near future.[6] Even microlevel research conducted in developing countries on the effects of factors such as class size and teacher qualifications on student achievement (let alone broader social and economic outcomes), has seldom demonstrated clear positive impacts (but see Birdsall & Behrman, 1983, on the rate of return to investments in educational quality in Brazil). This does not mean that quality isn't important. Effects of quality may be subtle, requiring a long gestation period before they can be detected, or detectable only after universal access to education has been achieved.

Nearly all EIM equations employ cross-sectional level variables rather than change variables. While Wheeler (1984a, 1984b) and a number of other economic and demographic researchers have advocated using change variables as both dependent and independent measures, we decided the theoretical advantage of that approach — the reduction of an artifactual correlation across development indicators due to natural growth — was outweighed by the computational burden it requires and by the compounding of the error variance when two variables are combined into a single change variable. Some endogenous variables appear both on the left- and right-hand side of some equations. This would appear to require simultaneous equation estimation techniques. However, in all of these cases the variable appearing on the right-hand side is the lagged version of an endogenous variable appearing in other equations on the left-hand side, so the model is recursive, allowing the analyst use to single equation estimation techniques.

Given its purpose and the above limitations, we must stress that the EIM is not intended to be definitive about the impact of education on a particular social or economic indicator. Indeed, using the EIM to explore specific relationships between indicators, one by one, as has already been done in the literature, would detract from the model's strengths and intended purpose.

6. Even if standard evaluational testing procedures existed in every country (which they do not), the international comparability of such data would be low unless considerable coordination was used while collecting data. Such coordination efforts have occurred (notably the IEA study; Walker, 1976) in broad-based research, but a permanent infrastructure does not exist to sustain the regular collection of such data, due to political as well as economic and logistical constraints. Secondly, the student-teacher ratio has often been used as an indicator of educational quality, but cannot be construed to portray class size (a less-readily available statistic), since it does not consistently differentiate full-time practicing teachers from those holding administrative positions or teaching part-time. (See Heyneman, 1987, on standardized testing considerations for developing countries; Fuller, 1987, for a review of case studies on the learning effectiveness of diverse educational practices.)

Section IV: Model Development and Components

All estimation equations employed in the EIM were developed through empirical modeling efforts using the EIM database. The selection of predictors and their relationship to outcome variables were guided by research, and followed the general flow diagram presented in Figure 2. Specific equations were fitted empirically to the data, to predict outcomes at time t as a function of predictor variables at time t or t minus an appropriate lag. Thus, every equation was estimated using cross-sectional data, where the dependent variable was observed at time t, and the predictor variables were observed at time t or t minus a lag. The stability of the estimated equation was checked by serially re-estimating it for various years, so that, for example, the same equation was estimated with dependent variables at time t and t–5 and predictor variables at time t–10 and t–15. These cross-sectional estimations for various years were compared with each other, and finally, stability, parsimony, and fit were used to select the "optimal" estimation solutions from among all equations generated. These "optimal" equations are employed in the final model.[7] The EIM simulations for a subset of countries in the sample were then examined, to assess the model's capacity to produce realistic results.

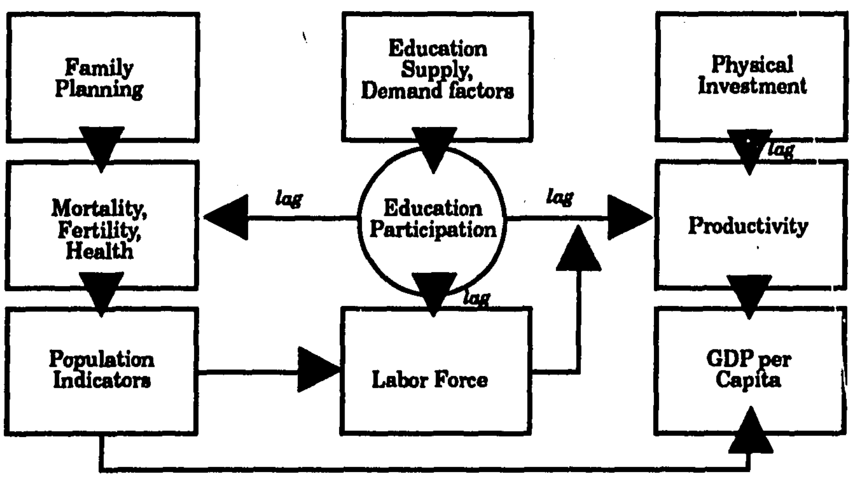
The EIM modeling efforts began by estimating the impact of educational supply and demand factors on male and female rates of primary educational enrollment and attainment. These primary educational participation rates, in turn, figured in the estimation of secondary enrollments; fertility, mortality, and population growth; patterns of labor force participation; and economic productivity. Detailed descriptions of the development and specifications of individual submodels are provided below.

Educational Participation Submodel

Educational participation at the national level may be construed as a function of (1) supply-side factors; and (2) demand-side factors.

The supply of education is affected by government policy decisions regarding the budget, the type and quality of education offered, and the administra-

Figure 2. Flow Diagram of EIM



7. Stability was assessed by comparing results predicting outcomes at two points in time (1975 and 1980, or 1980 and 1985). Parsimony was guided by a process of stepwise backward deletion, whereby variables making no trend-level significant independent contribution to the equation were removed individually, with re-estimation after each removal; these steps were repeated until all remaining variables were significant at trend level or better (suggesting real rather than chance effects), with minimal reduction in overall explanatory power (as indicated by R^2 adjusted for the number of variables). Fit was assessed through examinations of adjusted R^2, which represents the percentage of variance explained by the equation.

Gross enrollment rates for primary and secondary education, disaggregated by gender, constitute the EIM's principal indicators of educational participation.

tive organization of the educational system; and also by the prevailing costs and availability of educational materials, techniques, and personnel. These factors are associated with per student costs and, ultimately, in the number of student places and the quality of education a given budget can provide. Demand-side factors in educational participation include sociocultural attitudes toward education and its perceived utility, the private cash costs and opportunity costs of education, and potential demand produced by population growth.[8]

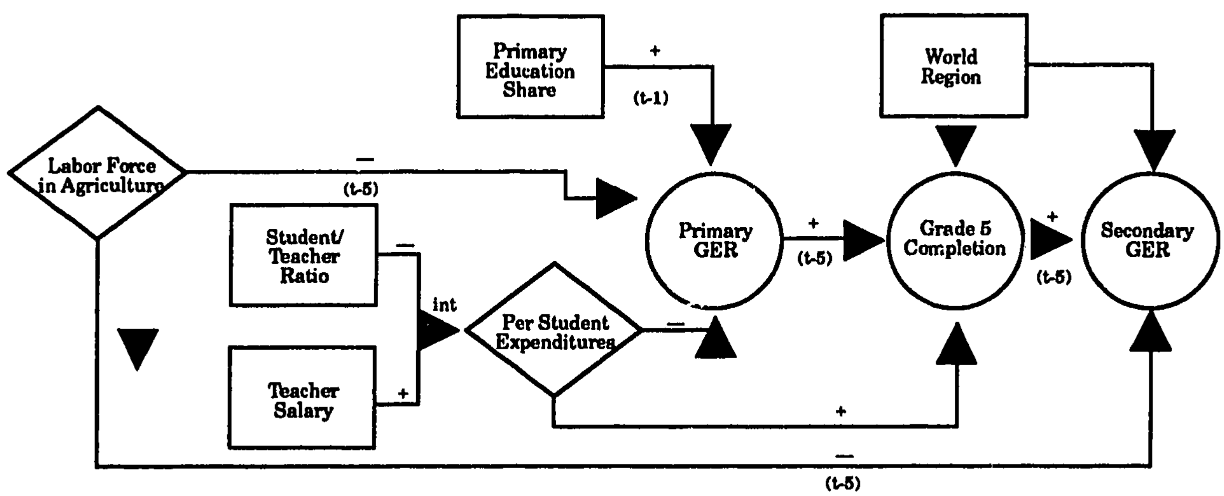
Gross enrollment rates (GER—defined as enrollment in a given school level divided by the population of appropriate age) for primary and secondary education, disaggregated by gender, constitute the EIM's principal indicators of educational participation. In addition, the EIM estimates gender-disaggregated fifth grade completion rates to provide a measure of educational participation that reflects actual attainment. Fifth grade completion rates are relatively free of some of the more severe problems of comparability and interpretation that plague gross enrollment rates.[9]

Figure 3 summarizes the EIM's education participation submodel in an integrated schematic form, showing the indirect as well as direct effects of educational investment policy variables, world region, and economic base (as proxied by labor force in agriculture) on educational participation. In this and all following submodel diagrams, exogenous input variables are represented by rectangular shapes, estimated educational outcome variables by circles, and other estimated outcomes by diamonds. Thus where a diamond or circular shape appears as an input variable in a given diagram, it represents an output from another submodel. The process of estimating the equations underlying these relationships is presented below.

Primary Enrollment

Model development for determining primary gross enrollment rates considered a number of variables reflecting both demand for and supply of educational opportunities and facilities. Estimating the supply-side contribution required, first, the estimation of expenditures per student. Efforts to estimate this variable were based on the observation that recurrent educational expenditures in most countries are overwhelmingly made up of teacher salary payments. The final equation is essentially an approximation of this relationship, with per student expenditures (XPSP; expressed as a proportion of GNP per

Figure 3. Educational Participation Submodel



8. Research suggests that cultural attitudes and cash cost factors are more likely to be associated with the educational participation of females than of males (Smock, 1981), although education that is insufficient or inappropriate for employment or other applications in a given milieu is being increasingly shunned by both genders. Poor families and farm families, in addition, with less disposable cash income than other groups, tend to depend on the labor contributions of children to a greater extent, thus differentially increasing the relative direct and opportunity costs for these groups.

9. Gross enrollment rates, while the most widely reported and accessible cross-national indicators of participation, are far from ideal. As currently reported, such figures do not reflect actual attendance or absenteeism and may be differentially subject to overreporting. Gross enrollment ratios aggregated across educational level are not precisely comparable for other reasons as well, such as differences in the length of each level across systems ("primary education," for example, may include from four to eight grades, depending on the system), or in repetition rates, which over time may inflate apparent enrollments without detection.

capita) estimated as the product of average teacher salary (TSALRT; expressed as a multiple of GNP per capita; circa 1982) and the inverse of the student-teacher ratio (ISTRP) (1985 model; n = 40):

$$XPSP(t) = \underset{(3.19)}{0.024} + \underset{(15.81)}{(0.922)}*TSALRT*ISTRP(t) \qquad (R^2=.865)$$

In other words, expenditures per student will be higher where teacher salaries are relatively high and where the student-teacher ratio is low[10]. Other estimation attempts included relative economic strength as represented by GNP per capita in linear and logged specifications, and expenditures on teaching materials per student (expressed as a proportion of GNP per capita). However, these variables were insignificant in the presence of the above product term.

Supply-side input variables for estimating primary gross enrollment rates included capital and recurrent expenditures in primary education as a proportion of GNP (EDSH*PEXP); and the per-student expenditures term estimated above.[11] Demand-side input variables included percent of labor force in agriculture as a proxy for proportion of rural population (LAGRI); GNP per capita (XPSP); the population growth rate over the previous 5 years; and dummy grouping variables for geographic region (Asia, Latin America, Middle East/North Africa, and subSaharan Africa). Modeling for primary school enrollment rates of females (GER1F) and males (GER1M) produced the following equations (1985 models, N = 44):

$$GER1F(t) = \underset{(15.08)}{119.943} - \underset{(3.03)}{0.362}*LAGRI(t-5) + \underset{(5.50)}{1858.146}*EDSH*PEXP(t) - \underset{(8.06)}{324.854}*XPSP(t) \qquad (R^2 = .686)$$

$$GER1M(t) = \underset{(19.05)}{119.325} - \underset{(2.18)}{0.205}*LAGRI(t-5) + \underset{(6.02)}{1600.117}*EDSH*PEXP(t) - \underset{(9.19)}{291.565}*XPSP(t) \qquad (R^2 = .715)$$

The results support our expectation that educational supply variables play a critical role in both female and male enrollments. The share of GNP allocated to recurrent expenditures in primary education (EDSH*PEXP) had an important positive effect, while per student expenditures as a proportion of GNP per capita (XPSP) had a negative effect, demonstrating the opposing forces of the level of social interest in education versus the average cost of educating an individual pupil. Capital expenditures in education and student-teacher ratio did not add a significant or meaningful contribution, and were removed from both equations.

When demand-side variables were looked at, there was for both female and male enrollment rates, a negative effect from a relatively high proportion of rural population, proxied by the proportion of the labor force in agriculture (LAGRI). This supports other research findings that rural areas have lower participation rates. Regional/cultural effects were also tested with the use of intercept dummy grouping variables. While Middle East/North African cultural/regional factors appeared to have a negative effect on female enrollments in the 1980 model, this effect was not replicated in 1985. No other regional grouping effects were found for either male or female primary enrollments. GNP per capita and 5-year population growth, lagged 5 years, added negligible or inconsistent contributions, and were removed. Excluding them did not affect the overall magnitude or significance of the remaining effects.

Fifth Grade Completion

The fifth grade completion rate (PEDC) is useful because it gives an indication of the success of the school system in producing graduates, which gross enrollment rates alone do not provide. The best equations for females and males were the following (1980 models; F, n = 49; M, n = 50):

$$PEDCF(t) = \underset{(2.50)}{-24.582} + \underset{(2.31)}{0.165}*GERF(t-5) + \underset{(8.28)}{19.906}*\ln(XPSP*GNPPC(t)) - \underset{(5.58)}{27.515}*LAC \qquad (R^2=.664)$$

$$PEDCM(t) = \underset{(1.79)}{-18.084} + \underset{(8.97)}{21.287}*\ln(XPSP*GNPPC(t)) - \underset{(6.17)}{27.800}*LAC \qquad (R^2=.645)$$

10. In all equations, the R^2 is always the adjusted R^2, and the t-statistics appear in parentheses below each relevant coefficient.
11. These variables must be understood to serve as imperfect, aggregate proxies for much important information, obscuring as they do the ratio of direct educational expenditures to administrative expenditures, and the specific costs and effectiveness of different types of educational materials, programs, and personnel.

For both genders, per student expenditures (XPSP*GNPPC) have a strong positive impact on primary school completion. The modest effect of the lagged gross enrollment rate for girls (but not for boys) suggests that when initial demand for and/or access to schooling of girls (as proxied by GERF) are high, completion of primary school is also likely to be high. This relationship is not significant for boys. Given their level of spending and girls' enrollment, Latin American and Carribean (LAC) countries as a group have lower completion rates for both girls and boys than other regions.

Secondary Enrollment

To estimate secondary enrollments (GER2F and GER2M), the interaction term, GER1 * PEDC, lagged 5 years, was used to give an approximation of the proportion of school-age children who complete primary school, and are thus eligible to become part of the GER2. The best-fitting equations possessed the following parameters (1985 models; n = 52):

$$GER2F = 42.894 + .00328*GERF(t-5)*PEDCF(t-5) + 15.355*ASIA + 8.511*LAC - .566*LAGRI(t-5)$$
$(R^2=.798)$ (5.02) (5.27) (2.83) (1.95) (5.73)

$$GER2M = 54.526 + .00253*GERM(t-5)*PEDCM(t-5) + 19.094*ASIA - .594*LAGRI(t-5)$$
$(R^2=.665)$ (6.24) (3.48) (2.97) (6.15)

For both males and females, the best-fitting equations indicated an important positive impact of the GER1*PEDC term. Particular regional factors (as proxied by ASIA and LAC) also had significant, although small effects. The proportion of rural or agricultural population (LAGRI) had an important negative effect for both male and female secondary enrollment, suggesting a greater opportunity cost of educational participation in rural areas. Population growth lagged by 10 years had no consistently significant effect for either the male or female secondary enrollment rate, and was removed from both equations.[12] Even in the absence of primary enrollment lagged by 5 years, supply-side variables exerted minimal, nonsignificant direct effects and were also removed. These factors have an indirect effect through their impact on the primary enrollment rate.

The EIM computation of total enrollment and fifth grade completion rates, as well as indices of gender disparity for each school level (i), are based on the gross enrollment rates (GER), as follows:

$$GER(i,t) = (GER(i,f,t) + GER(i,m,t)) / 2$$

$$DIND(i,t) = (GER(i,m,t) - GER(i,f,t)) / (GER(i,m,t) + GER(i,f,t)$$

For the gender index, these computations are meant to single out the effect of gender on the rates by abstracting from absolute numbers, and are therefore expressly not weighted. Using a population weight would be a more accurate way to calculate a total gross enrollment rate, but would require a projection of age specific population groups. These projections would increase the computative costs of this tool beyond the benefit of a marginal increase in accuracy.

Demographic Submodel

Population research has consistently provided compelling evidence that schooling and literacy of women reduce fertility (Caldwell, 1986; Cochrane, 1979, 1983; Kasarda, Billy, & West, 1986; LeVine, 1987; Moreland, 1982; Tan & Haines, 1984). In explaining such findings, researchers have argued that female education improves the understanding of biology, enhances acceptance and correct application of birth control methods, and delays marriage, all of which may be expected to reduce fertility rates. In addition, because educational participation tends to extend the length of the child's economic dependency on the family, it may shift attitudes toward reduced family size (Cochrane, 1979; Gomes, 1984). On the other hand, educated working women are more likely to breastfeed each child for fewer months, a practice

12. A significant negative effect of population growth at lag-10 (t=2.31) was apparent for female secondary enrollment in 1975, suggesting that when the supply burden increases, female enrollment is the first to suffer; but this effect was not replicated for 1980 or 1985 or for male secondary enrollment in either year.

Education may also have a direct effect on child health and survival...

which may contribute to shorter spacing between births and a potential increase in fertility.

Mortality rates and life expectancy are other important factors in the population growth curve. Cross-national and intra-country findings in a number of developing countries have consistently shown an important relationship between education or literacy and life expectancy of the next generation, principally through improvements in infant and child survival rates (Caldwell, 1986; Cochrane, Leslie, & O'Hara, 1982; Cochrane, O'Hara, & Leslie, 1980; D'Souza & Bhuiya, 1982; Hobcraft, McDonald, & Rutstein, 1984; LeVine, 1987). Analysts have hypothesized that both the knowledge and the increased earnings potential gained through education enable parents to provide a healthier environment for their families, although the processes or mechanisms by which school learned knowledge is translated into better health behaviors are still unclear (Eisemon, 1988; LeVine, 1987). Education may also have a direct effect on child health and survival, to the extent that schools provide children with informal health care, immunizations, and dietary supplements (Caldwell & Caldwell, 1985; Eisemon, 1988).

A few researchers have examined the effects of education disaggregated by gender, by looking at the probable contributions of maternal and paternal education to children's life expectancy. Paternal education has been hypothesized to have a positive effect, principally through increased income and the "market" value of education, allowing improvements in living standards and the use of health-promoting goods and services. Female or maternal education may have both market effects (which may be negative as well as positive, since formal labor may take mothers away from childrearing activities), and nonmarket effects, through the influence of education on childrearing and household resource management (O'Hara, 1980). When possible or relevant, both left- and right-hand side variables have been gender-disaggregated in the model equations. For example, the data set did not include data on infant mortality, or age of marriage, by gender. The key dependent variables to disaggregate by gender were the educational variables, which were in turn used as independent variables in other equations. In some cases, due to data limitations, these latter equations were gender-disaggregated only to the extent that gender-specific independent variables were used, rather than having gender-specific dependent variables as well.

The balance between the positive and negative effects of education on population growth appears to be tempered by levels of economic and educational development (LeVine, 1987). In the early stages of development, developing countries first tend to exhibit education's effects on improved health, infant survival, and life expectancy, and therefore may experience an increase in population growth. The fertility decline associated with education, on the other hand, tends to occur only at later stages of economic development and after more than a few years of education (Kasarda, Billy, & West, 1986; Wheeler, 1984a).

A diagram representing the EIM demographic submodel is presented in Figure 4. Individual components of the submodel are discussed below.

Total Fertility Rate

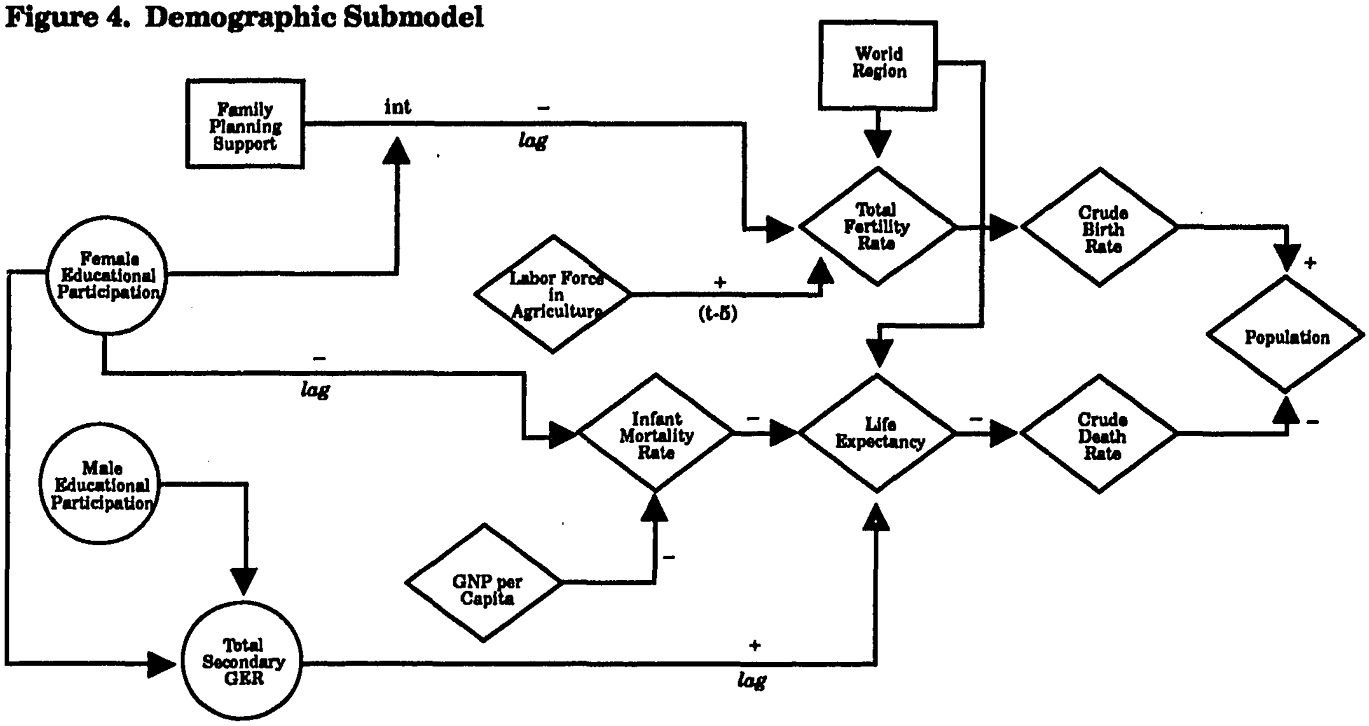
On the basis of theoretical considerations and research results, the EIM efforts to model the total fertility rate (TFR) included female educational attainment (fifth grade completion rate) in the presence of other relevant factors, including average female age of marriage (circa 1975), GNP per capita, level of urbanization, female labor force participation rate, male enrollment rates, national level of support for family planning (circa 1975)[13], and geographic region. The female fifth grade completion rate was lagged 10 years in all attempts to approximate the period of time from grade five attendance to childbearing age. The best-fitting equation contained the following parameters (1985 model; N=44):

$$\underset{(R^2=.737)}{TFR} = \underset{(29)}{6.128} - \underset{(9.8)}{0.00035} * [GER1F(t-20) + GER2F(t-20)] * FPSCORE + \underset{(2.8)}{0.62} * AFRICA$$

13. This factor is represented by an indicator constructed by the Population Crisis Committee (1987), based on information from the Developing Country Birth Control Survey. The index combines separate ratings on the availability of six birth control devices and four other family planning support categories (service related activity, information outreach, private sector involvement, and government spending and policies), resulting in an overall 100 point score, with a high score indicating high support for family planning practices.

...female education has its greatest impact on fertility when combined with support for family planning.

Figure 4. Demographic Submodel



The combined effect of primary and secondary female enrollments (GER1F and GER2F) was stronger than that of either alone, and most pronounced in interaction with the level of government family planning support (FPSCORE). That is, increasing female education participation alone, or family planning alone, appears to be much less effective than if both are increased together. The mean valued of the FPSCORE variable was 25, with only 8% of the countries scoring higher than 75. For a country with a very strong family planning program (scoring, say, 75), an increase in the GER from 50% to 100% therefore reduces the total fertility rate by approximately 1.3 children, whereas for a country with average family planning support, the same increase in education reduces the rate by only 0.4 children. This result supports the conclusion of previous research (Wheeler, 1984b) which indicates that female education has its greatest impact on fertility when combined with support for family planning. High levels of female enrollment can more than triple the effectiveness of family planning efforts.

Cultural factors (proxied by the dummy regional grouping variable AFRICA) also appear to effect fertility. GNP per capita, age of marriage, female labor force participation, and male education had little additional impact. The superiority of linear over log-linear specifications suggests that, for the levels of development represented in the sample, the effect of increasing female educational attainment on fertility remains just as important in countries with relatively high female educational attainment rates to begin with, as in countries with low rates.

Infant Mortality and Life Expectancy

In efforts to model infant mortality (IMR), the impact of female educational participation, lagged to approximate the period of time from beginning of schooling to child-bearing age, was considered in the presence of other potentially relevant factors, including GNP per capita, average female age at marriage, level of urbanization, male enrollment rates, and geographic region.[14] The best-fitting equation is presented below (1985 model; N = 77):

$$\ln(IMR) = 5.863 - 0.00221*GERF(t-20) - 0.0289*GER2F(t-20) + 0.173*\ln(GNPPC)$$
$$(R^2=0.839)\ (24.08)\ (1.55)\ (8.55)\ (3.87)$$

14. The availability of health care as represented by physicians per 1000 population would be a logical additional right-hand variable in infant mortality and life expectancy; however, a high rate of missing data on this variable with very limited variability precluded its use in the final modeling efforts.

Thus, both primary and secondary female enrollment rates at lagged by 20 years, a rough proxy for level of maternal education, appear to reduce the infant mortality rate. GNP per capita added to this reduction. Average female age at marriage, level of urbanization, and geographic region made negligible contributions to the equation and were removed. Log-linear specification of the model produced a fit superior to linear specification, suggesting that the effect of increasing female enrollments on fertility diminishes as relatively high rates of enrollment are achieved.

The effect of lagged male enrollment rates, as a proxy for the contribution of father's education, was also examined. Male enrollment rates made a small contribution to reduced infant mortality when they replaced female enrollment in the equation, but their effects were much weaker than for female enrollment rates alone, and became negligible and insignificant when both male and female rates were included in the equation.

The EIM estimations of life expectancy (LEXP) included: 1) gender-disaggregated gross enrollment rates, lagged 20 years to represent maternal and paternal education; 2) GNP per capita as a proxy for living standards; and 3) geographic region, which may reflect variation not only in culture but also in health services, sanitation, and disease prevalence. Modeling efforts produced the following best-fitting equation (1985 model, N = 78):

$$\begin{array}{llllll} LEXP = & 73.528 & -.185*IMR(t) & +.073*GER2T(t-20) & -2.932*AFRICA & -2.464*ASIA \\ (R^2=.973) & (83.19) & (26.24) & (3.23) & (6.45) & (4.88) \end{array}$$

The results suggest that parental education (as proxied by GER2T at t–20) contributes directly to improving life expectancy, above and beyond the overwhelming proportion of LEXP explained by IMR (and the indirect effects of female education through IMR). The coefficient for total gross secondary enrollment rates is marginally higher than that of either gender separately. Regional factors (proxied by AFRICA and ASIA) made additional contributions to life expectancy. Linear specification of the relationship among variables was superior to log specification, suggesting that for the levels of development represented in the sample, increases in educational participation remain important even for countries with relatively high enrollment rates.

Population and Population Growth

The computation of population and population growth requires projections of crude birth and death rates (CBR and CDR). The equations which were estimated to produce these rates employed lagged values for CBR and CDR and current values for TFR and LEXP (1980 and 1985 data pooled, N=160 for CBR; N=151 for CDR):

$$\begin{array}{llll} CBR(t) = & 1.3758 & + 0.4579*CBR(t-5) & + 3.58*TFR(t) \\ (R^2=.959) & (1.7) & (8.3) & (10.8) \end{array}$$

$$\begin{array}{llll} CDR(t) = & -10.0904 & + 0.4518*CDR(t-5) & + 910.6913/LEXP(t) \\ (R^2=.977) & (-11.4) & (10.8) & (11.4) \end{array}$$

From these results we can conclude, given lagged variable coefficients of about .45 in both equations, that roughly half of the current value of the crude birth and death rates is explained by demographic momentum or inertia.

The estimated crude birth and death rate values were then employed in the EIM to compute an estimate of the total population:

$$POP(t) = POP(t-1) * (1 + CBR(t)/1000 - CDR(t)/1000)$$

The decision to replace standard cohort-component projections with the above simplified approach was made in the interest of computational simplicity and data availability. Forty-year (1980 to 2020) test-case total population projections for Mali, Bolivia, Tunisia, Indonesia, and the Dominican Republic were made using this method. The average absolute error, compared with the cohort-component method applied to the same countries for the same period, was less than 2% after forty years. In comparison, the population projections for the year 2020, from a standard cohort-component method such as that used by the World Bank, changed by more than 8% from their own values over a four year period (comparing the projections made in 1985 to those made in 1989), due to changes in starting year values and projected values of critical parameters. In short, the EIM's simplified approach to estimating total population is offered as a justified innovation, especially for policy dialogue purposes, given that the standard approach is often based on grossly uncertain estimates of base year data, and on highly speculative projections of fertility and mortality. (For a more extended discussion of these issues see Crouch, 1991).

If a short-cut method is to be used, the reader might wonder: Why the EIM does not simply model the crude rates as functions of the education and other variables directly, in place of using the two-step process described above? The answer is that the two-step method preserves both the direct effect of the education variables on the behavioral demographic variables (such as TFR), and the inertial nature of the cohort-component method. If we modeled current crude birth and death rates as functions of the relevant "independent" variables (e.g. education), then the effect of the "independent" variables on the crude rates would be instantaneous, rather than lagged, and the inertial effect would be lost. If lagged crude rates were used in combination with the "independent" variables, then the explanatory power of the independent variables on the underlying behavioral variables (such as the fertility rate) would be lost, thus reducing the model's richness.

Labor Force Participation Submodel

Meaningful research on the relationship of education to labor force structure and participation requires special attention to sector-specific and gender-specific patterns. In general, increased educational participation has been associated with "qualification escalation" (Dore, 1976), whereby an employer's educational criteria for filling a particular position may be inflated beyond the actual job requirements, simply as a selection mechanism. In such contexts, employment or labor force participation rates may be expected to be positively related to higher rates of educational attainment.

Other research, however, has suggested that for many employers, job experience plays a much greater role in hiring decisions than do educational credentials (Simmons, 1974, 1979). Whether or not a more educated population is more likely to be employed is also a function of the structure of the labor market and the types of employment opportunities within it (Eisemon, 1988). This array of potentially counteractive factors, combined with the lack of information on informal-sector participation (by all estimates an extremely important share in overall labor in many developing countries), contributes to the lack of attempts to explain cross-national, aggregate participation rates in the literature and the murkiness of results that do exist, especially for males.

Results for sector-disaggregated and female labor force participation have been somewhat more encouraging. Education has been associated with rural-urban migration and therefore with urbanization of the population (and the labor force), due in part to a greater expectation of increased earnings with increased education in the urban sector (Barnum & Sabot, 1976). Formal education has also been found to be positively associated with women's participation in wage-labor and salaried labor, typically the only "labor" represented in published figures. The reason for this relationship between education and labor force participation may be that education exposes girls to nontraditional attitudes, values, and information and to a bureaucratic, work-like public institution. It also imparts specific marketable skills such as literacy or bilingualism (Eisemon, 1988; Psacharopoulos, 1984).

Thus theory and research have underscored the importance of sector- and gender-disaggregated approaches to examining the relationship between educational participation and labor force participation. Unfortunately, the absence of sufficient and comparable cross-national information on educational characteristics of the labor force disaggregated by economic sector or urban or rural environment, on sectoral productivity by gender, or on migration patterns and other factors implicated in labor force participation trends has limited the range and specificity of estimations in our modeling attempts. EIM efforts to model the relationship of education to productivity were thus restricted to an aggregate approach. Data disaggregation by gender and by economic sector is encouraged, and should be used whenever possible in country-specific applications of the model.[15]

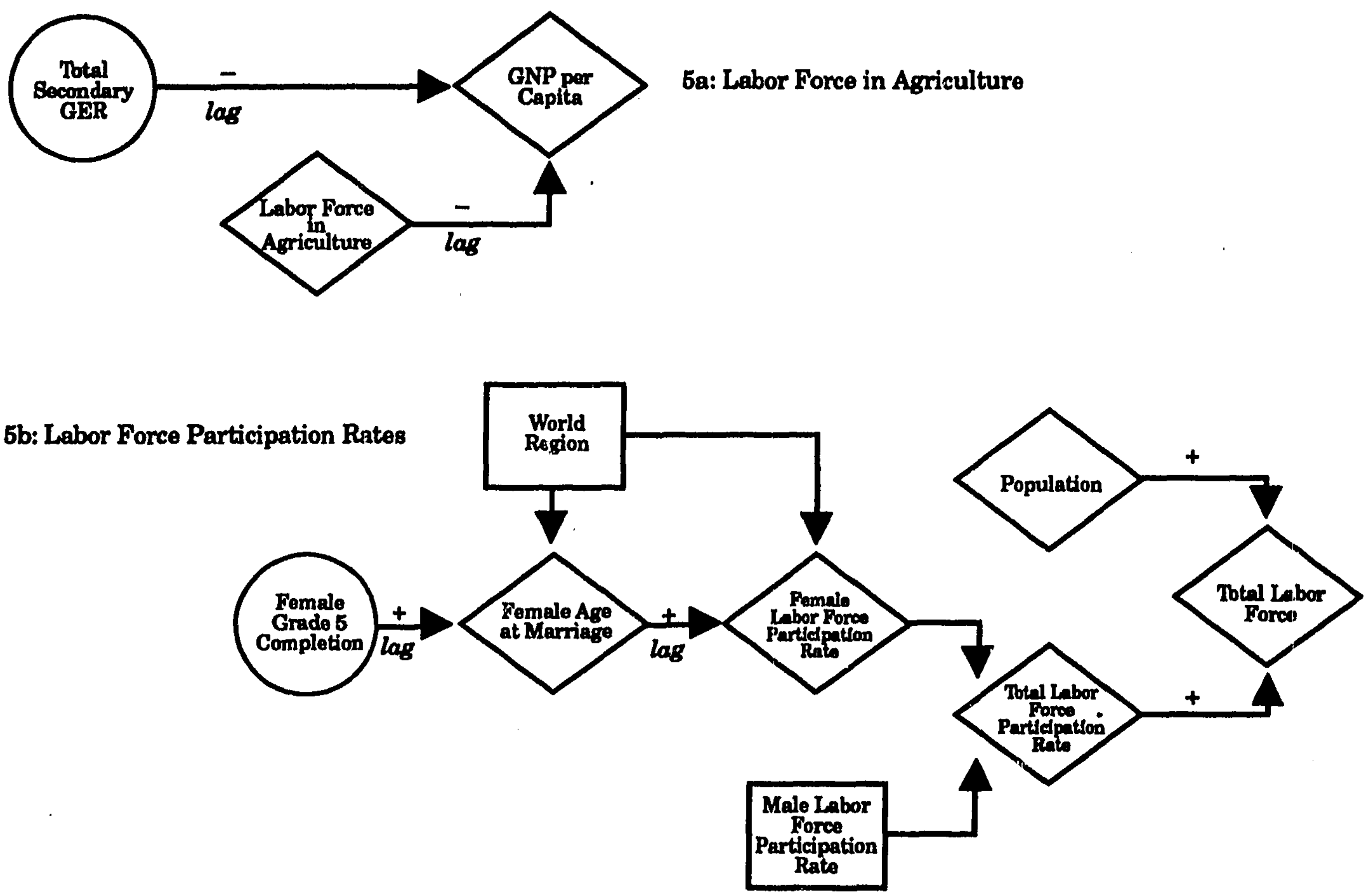
Figure 5 summarizes the labor force participation submodels employed in the EIM. Because of the data limitations, modeling efforts were restricted to the estimation of labor force participation in agriculture (Figure 5a), and the female labor force participation rate, which feeds into the estimation of the total labor force participation rate and total labor force (Figure 5b). Male labor force participation rates are held constant at 1980 rates for the period of all simulation runs since we and other researchers' have found them to be notoriously difficult to estimate, and since they have not been observed to fluctuate greatly across time.

Labor Force in Agriculture. Estimates of the proportion of the labor force in agriculture (LAGRI) resulted in the following best-fitting equation (1980 model; N = 75):

$$\begin{array}{llll} LAGRI(t) = & 150.399 - 14.350 * \ln(GNPPC(t-10)) & - 8.861 * \ln(GER2T(t-20) \\ (R2=.736) & (14.00) \qquad\qquad (6.11) & \qquad (5.50) \end{array}$$

15. Gender-specific effects of educational participation on economic prosperity have been examined by Benavot (1989), who concluded that his findings supported a positive, largely "institutional" effect of the primary education of females on GNP per capita. Further, to the extent that female education tends to reduce population growth, some have argued for the indirect contribution of female education contributes to increased GNP per capita through this demographic effect. Of course, such indirect feedback mechanisms may also operate with a considerable lag (e.g., 20 to 30 years).

Figure 5. Labor Force Participation Submodel



Consistent with results in the existing literature, the proportion of the labor force in agriculture was found to be negatively related to lagged overall economic prosperity as reflected in GNPPC, and to lagged educational participation in secondary school (GER2T, as defined on page 12), a result likely to reflect the tendency of the educated to migrate to urban areas.

Labor Force Participation Rates

Estimations of female and total labor force participation rates begin with the estimation of female age at marriage, representing the opportunity cost or trade-off between marriage and labor force participation observed for women in many developing countries. Modeling efforts produced the following equation (N=22):

As expected, educational participation appears to delay marriage for girls; regional factors (proxied by AFRICA, ASIA, and LAC) also contribute to differences in age at marriage. While some time lag between PEDCF (female fifth grade completion rate) and AGEMARR would be theoretically appropriate, the available data on both PEDCF and AGEMARR did not permit this lag in estimation efforts. Both AGEMARR and earliest PEDCF information are circa 1975.

Input variables that were considered in attempts to model the female labor force participation rate (LFPRF) included female primary and secondary enrollment rates, lagged 20 years to approximate the period of time from beginning schooling to potential entrance into the adult labor force; GNP per capita; average age at marriage; fertility rate; proportion of

$$\underset{(R^2=.567)}{AGEMARR} = \underset{(1.22)}{4.652} + \underset{(4.22)}{3.784}*\ln(PEDCF(t)) - \underset{(2.09)}{1.770}*AFRICA + \underset{(2.57)}{2.549}*ASIA + \underset{(1.92)}{1.633}*LAC$$

the labor force in agriculture; and geographic/cultural regions. Estimation efforts resulted in the following best-fitting 1985 equation (N=33):

$$\text{LFPRF}(t) = \exp(-4.897) * \text{pwr}(\text{AGEMARR}, 2.630) * \exp(0.829 * \text{AFRICA}) * \exp(-0.846 * \text{MENA})$$
$$(R^2=.516) \quad (1.67) \quad (2.75) \quad (2.91) \quad (3.66)$$

These results suggest that age at marriage and regional/cultural factors make substantial contributions to female labor force participation. Given the important role of female educational participation in the determination of age at marriage (see above), one may also posit a positive but indirect effect of educational participation on the female labor force participation rate.[16] The equation also suggests that the African region as a whole (AFRICA) tends to have a relatively higher rate of female labor force participation than age at marriage would predict, while Middle East/North African (MENA) societies appear to have lower female labor force participation than age of marriage would predict. Economic prosperity, proxied by GNP per capita, was removed from the equation as its contribution was negligible in the midst of socio-cultural factors.

Total labor force participation rates and total labor force are then computed from the values obtained for female labor force participation and from the constant 1980 values for male participation.[17]

$$\text{LFPR}(t) = (\text{LFPR}(f,t) + \text{LFPR}(m,t)) / 2$$

$$\text{LABOR}(t) = \text{POP}(t) * \text{LFPR}(t) / 100$$

Economic Productivity Submodel

Determining what types and amounts of educational investment contribute most to economic productivity and GNP growth is a critical concern of many economists and development planners. In most macrolevel studies addressing this question, education is positively associated with economic growth, increased productivity, and more efficient management. Lower, less expensive levels of education have tended to show the highest social rates of return.[18]

Increased education of the labor force has been hypothesized to enhance economic growth and labor productivity by the adoption and correct application of new technologies, by contributing to improved selection and more efficient allocation of production inputs, by increasing the worker's competencies and gains from job training, and by improving access to price and technology information. The positive effects of education on productivity, therefore, tend to be greatest in environments where new technologies are available (Schultz, 1987; Lockheed, Jamison, & Lau, 1980), and where training is an important component of efficient job performance. Positive effects of education on productivity have often been substantiated in the domain of agricultural productivity (Jamison & Moock, 1984; Dhakal, Grabowski, & Belbase, 1987; Phillips & Marble, 1986; Lockheed, Jamison, & Lau, 1980). Results of such studies have included rates of return averaging 6 to 7% for four years of education. The importance of such findings is underscored by the typically lower rates of educational investment and participation in rural areas — where, ironically, primary education may have a greater impact than in the urban sector.

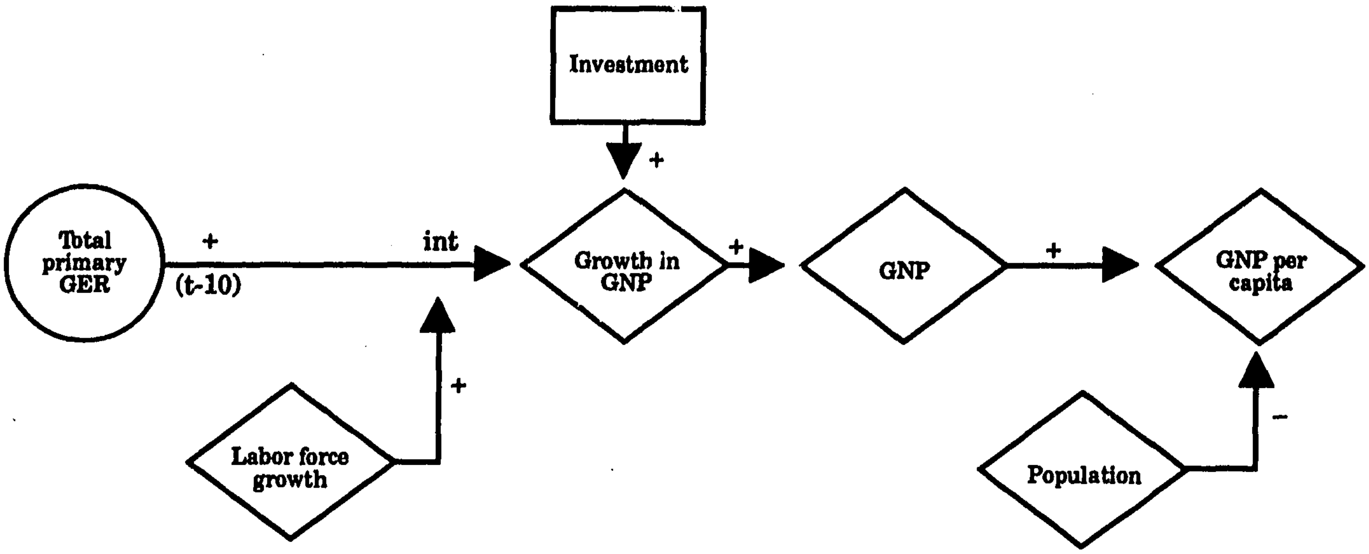
The effect of educational participation on economic productivity was measured in the EIM using a "growth accounting" framework similar to those developed by Robinson (1971), Hagen and Hawrylyshyn (1969), Wheeler (1984a and 1984b), and Ram (1987). A very recent example of this type of exercise can be found in the World Development Report 1991 (World Bank, 1991).

Figure 6 presents a schematic of the EIM economic productivity submodel. In addition to the direct effect shown, educational participation has indirect impact on GNP growth and GNP per capita, respectively, through its effects on labor force (see Figure 5b) and population (see Figure 4).

In the estimation of GNP growth, the dependent variable (GNPGR) represents the annual percentage change in GNP over the period 1965-1980.[19] A long

16. In the best-fitting 1980 equation for LFPRF, the female secondary enrollment rate had a significant direct effect, but this effect was not replicated for 1985. In the presence of GER2F, furthermore, age at marriage (AGEMARR) was found to have a small but negative impact on female labor force participation, while in the absence of GER2F as a direct predictor, the overall effect of AGEMARR tends to be positive.
17. Weighting the participation rates with gender-specific population proportions would be slightly more accurate, but would require gender-specific projection of the population. Given the purpose of this simulation model, and the importance of fast computability for "real-time" policy dialogue, the significant computational burden was judged to outweigh the small gain in accuracy.
18. Higher education may initially show a negative social rate of return (due principally to its expense and the high degree of public subsidization in most developing countries), but eventually produces positive returns after 5 to 10 years (McMahon, 1987; Behrman, 1987). To the extent that it has been associated with technological change (Horton & King, 1981), higher education may make important indirect contributions to growth and productivity as well.
19. This value is proxied by figures for GDP growth drawn from World Bank (1988b) sources.

Figure 6. Economic Productivity Submodel



time period was used to minimize the effects of short-term fluctuations. The independent variables were the average annual rate of growth of the labor force from 1965 to 1980 (LABGR), the average annual gross domestic investment as a percentage or "share" of GNP over the same period (INSHAV), the average annual rate of growth in the terms of trade between 1970 and 1980 (AVGTT), and the total (male and female) primary gross enrollment ratio (GER1T) in 1960. Following the tradition of growth accounting models, the investment share, as opposed to the growth rate of the capital stock, was chosen due to the well-known problem of the lack of capital stock data for a large number of countries. Since the gross enrollment ratio is a measure of the educational opportunity of a cohort, we added to the traditional growth accounting equation the notion that the growth of the labor force matters only to the extent that it had the opportunity to be educated. Therefore, the estimated equation (N=72) was:

$$\underset{(R^2=.254)}{GNPGR} = \underset{(0.8)}{0.894} + \underset{(3.6)}{0.139*INSHAV} + \underset{(2.6)}{0.00993*GER1T(t-10)*LABGR} - \underset{(.4)}{0.18*LABGR}$$

This equation confirms the idea that the growth of the labor force is a significant factor in combination with educational opportunity. Dropping LABGR yields:

$$\underset{(R^2=.254)}{GNPGR} = \underset{(0.7)}{0.603} + \underset{(3.6)}{0.139*INSHAV} + \underset{(3.0)}{0.00898*GER1T(t-10)*LABGR}$$

which is the model used in the simulations.[20] An attempt was also made to substitute the change in the terms of trade, as a proxy for changes in the foreign exchange constraint on investment, for the overall investment term, with the following results (N=66):

$$\underset{(R^2=.365)}{GNPGR} = \underset{(7.5)}{3.36} + \underset{(4.4)}{0.157*AVGTT} + \underset{(4.1)}{0.0107*GER1T(t-10)*LABGR}$$

The coefficient for education and labor is essentially the same in both models. Though this last model is slightly better in terms of explaining and confirming the importance of the education and labor term. The terms of trade, however, can hardly be con-

20. In the simulations, a version without an intercept was used, where the coefficients were 0.161 and 0.00959 respectively.

sidered a policy variable; and therefore, this model is not suitable for comparisons of the effectiveness of educational "consumption" (as a determinant of GER) with investment, as defined in the national accounts. Since the inclusion of both terms of trade and investment indicators greatly reduced the level of significance for the investment term, we chose to use only the investment indicator because of its higher relevance for policy analysis. In all of these equations for growth of GNP, it would have been comforting to obtain stronger statistics of significance and, especially, greater explanatory power. The results, however, are highly consistent with the growth accounting literature. Estimated parameters for all GNP growth equations are in the same range of magnitude as those estimated by Ram (1987) and by Robinson (1971), but the EIM estimations also show the importance of education. The explanatory power, while low relative to that of other equations in the model, is also in the range of most growth-accounting studies, including very recent ones (World Bank, 1991).

With the average annual growth in GNP thus estimated, the EIM then computes estimated total GNP and GNP per capita with the equations below:

$$GNP(t) = GNP(t-1) * (1+GNPGR/100)$$

$$GNPPC(t) = GNP(t) / POP(t)$$

Section V: Using Simulation Models in Educational Policy Dialogue

The ultimate aim of EIM, as a policy dialogue tool, is to assist education related groups in developing countries in explaining and defending education as a social and economic investment. In the struggle over budgetary allocations, ministries of education are often hard pressed to explain that education is not a form of current consumption (especially given that this is exactly how it is classified in the national accounts), but a form of highly productive investment. The EIM, in addition to other studies and results, can be used to make this argument in a consistent, numerical, and graphical fashion.

The results for the EIM were derived by comparing productivity and socioeconomic indicators in countries with very low levels of education participation with the same indicators in countries with medium to high levels of education participation. This being the case, the model can be valid in describing the likely impacts of improved access to education in countries such as Pakistan, Burundi, Sierra Leone, Yemen, Mali, Niger, Burkina Faso, Guinea, and others with similarly low levels of current educational participation. It can be applied in countries which have already achieved reasonably high levels of participation if budgetary cutbacks threaten these levels. With the appropriate data, it may also be applied to sub-national areas with low participation within countries which have a relatively high level of national participation.

The model should not, however, be applied as an argument for further expansion or quality improvements in countries that already possess medium-to-high levels of educational participation. In other words, the results of the model should not be extrapolated beyond the (qualitative and quantitative) range of observations over which it was estimated. (See also Model Limitations, page 9, for other important considerations and limitations in EIM use and interpretation).

With these restrictions in mind, the EIM can be used in various settings and with varying degrees of depth and cost.

The easiest and least expensive use of the EIM is for education ministry officials (or researchers at a private education interest group or foundation) to present the existing computer graphics storyboard to policymakers in national planning and finance offices. Depending on the presenter's background in social science research and knowledge of the issues, this presentation could be carried out with no training or support from either local or international consultants. For exampie, ministry officials with advanced degrees in research oriented social sciences, and with practical quantitative research experience, should require little or no training beyond a careful reading of this technical description. On the other hand, if presenters have little background in social science research and methods, it is likely that without some prior training from a consultant they will be unable to answer questions from counterparts in the finance or planning ministries. Thus, care needs to be exercised in the choice of presenters and in determining the degree of prior study and training needed to make a presentation.

...ministries of education are often hard pressed to explain that education is not a form of current consumption...but a form of highly productive investment.

United Nations/B. Wolff

A second, more complicated approach is to use the EIM simulation toole to produce results directly relevant to the country in question. As distributed, the EIM storyboard tells a generic story about the experience of the developing world, for example using dollars as the measure of income per capita, and average levels of fertility as applied to the sample of developing countries in the 1980s, etc. Adapting the model and the storyboard to illustrate local conditions would almost certainly require some highly trained foreign or national consulting assistance in modeling and computer graphics. The time required for these consultants could range from six to twelve person-weeks.

A third, and more ambitious approach would be to use the EIM as a framework or source of inspiration to re-estimate as many of the mathematical equations as possible, using data from the country in question. For example, data from regions or districts of the country could be used in the same way countries were used for the estimation of the EIM. Depending on users' interests and data availability, new variables, equations, and disaggregation levels that could not be considered at a cross-national level could also be introduced. Even more ambitiously, individual-level data from existing labor force, fertility, and other surveys could be used to establish individual-level estimates of the EIM equations. At this point, the EIM would cease to be illustrative, and would become a research tool for prescription of policy. This level of use would, of course, require a serious, well-funded research program, requiring one or more person-years of PhD trained social scientists.

Section VI: An Illustration with Data on Pakistan

To demonstrate the kinds of scenarios that can be produced using the EIM for policy dialogue we present a set of simulations using data from Pakistan. This set of simulations illustrates what could be done under the second use outlined on page 23. It is not, however, a full-scale example of such an exercise, since a real exercise of this type would require detailed work, preferably in-country, which is beyond the scope of this illustration.

In the simulations that follow, we compared several types of "policies." Tthe first of these is an education policy which would raise the level of commitment to primary education from 1.8% of GNP to 4.5% of GNP over a period of 10 years. The second policy change is a program of support to family planning that would raise Pakistan's family planning score (see definition, f.n. 13) from a rather low "29" to a moderately high "70" over the same period. Third, is a "combined" education and family planning scenario, where both goals are reached. The fourth scenario represents a "traditional" investment scenario, where the same increase of 2.7 (=4.5–1.8) percentage points is made in the proportion of GNP which is dedicated to the traditional investment categories defined in national accounts. Finally, a scenario was simulated that combines the above changes in traditional investment, educational investment, and support for family planning. All scenarios take 1985 as the point of departure (being in this sense "counter historical"), and reach full policy changes by 1995, after which the target policy levels are held constant. The results of all scenarios are contrasted to an extrapolation of the observed pre-1985 trend through the year 2015.

The table below summarizes key indicators resulting from all of the simulations.

As can be readily seen from the GNP PC row in the table below, dedicating 2.7% more of GNP to primary education (Ed Run) leads to roughly as much growth in income per capita as dedicating the same to traditional investment (Inv Run). In addition, however, dedicating these resources to education rather than traditional investments results in lower infant mor-

Noel McGinn

Results of Illustrative Simulations for Pakistan

		2015 outcomes					
Indicator	**1985 level**	**Base Run**	**Ed. Run**	**FP Run**	**Ed.&FP Run**	**Inv Run**	**Ed.&FP&Inv Run**
GER1F	34%	43%	67%	43%	67%	43%	67%
GER1M	62%	67%	88%	67%	88%	67%	88%
TFR	6.8	6.5	6.2	5.7	5.1	6.5	5.1
LEXP	51	60	61	60	62	61	62
POP grth	3.0%	3.3%	3.2%	2.8%	2.6%	3.3%	2.6%
POP (in millions)	96.2	242.9	242.3	226.3	224.7	243.1	225.0
IMR	114	70	63	70	63	69	62
GNP PC	$340	$592	$639	$617	$662	$655	$732

tality (63 as opposed to 69) and lower total fertility (6.2 as opposed to 6.5) than dedicating the resources to overall economic growth. Of course, this effect has a limit, since enrollment ratios much beyond 100% are not possible. It would seem a safe conclusion that investing in education until enrollment ratios are 100%, or nearly 100%, is competitive with investment as traditionally defined in national accounts. The implicit rate of return to primary education as calculated in this exercise is 10%, which is evidently about the same as it is to traditional investment.

A social investment program emphasizing family planning by itself has a greater impact on fertility than one emphasizing education alone; the family planning scenario leads to a fertility rate of 5.7 whereas education alone produces a fertility rate of 6.2. The two in combination, however, lower fertility to 5.1. Note that such a reduction in the fertility rate is possible through an increase in female enrollments to only 67% of the cohort (see row GER1F). To increase female enrollments beyond this level would require either further budget increases, or policies with female-specific impacts.

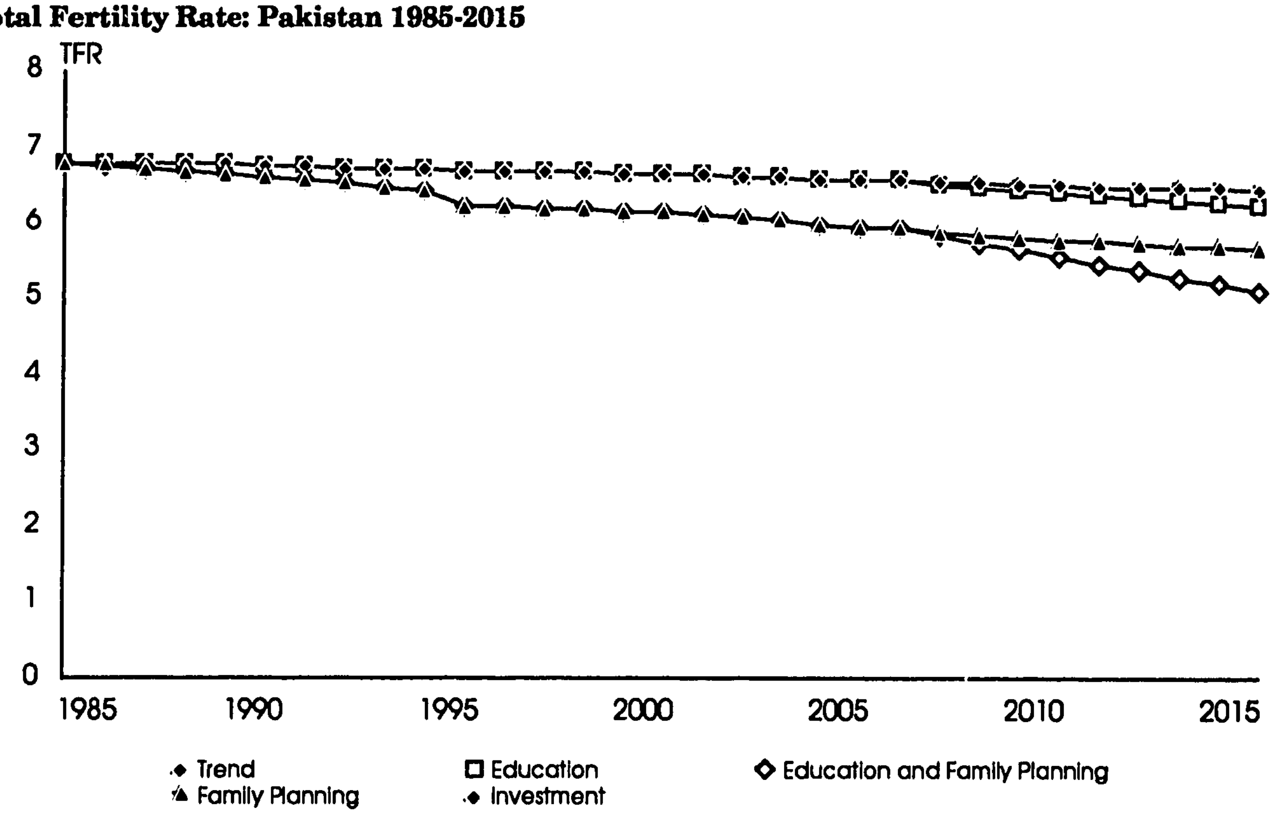
The path of these factors over time can best be seen by studying the following graphs.

The trend shows a slight lowering of the fertility rate, which also coincides with what would happen under the "Investment" scenario. An "Education" scenario leads to a lower fertility rate, but the onset of fertility decline does not start until 2005. (In reality it may happen a little sooner, perhaps by 2000.) In the "Family Planning" scenario, the onset of fertility decline is immediate, but tends to become flat by about the year 2000 under the assumption that support for family planning reaches a peak at 1995 and remains constant thereafter. A combined "Education and Family Planning" scenario has effects that are immediate, sustained, and steep.

The graph on the top of the next page summarizes the trends in the determinants of the fertility changes.

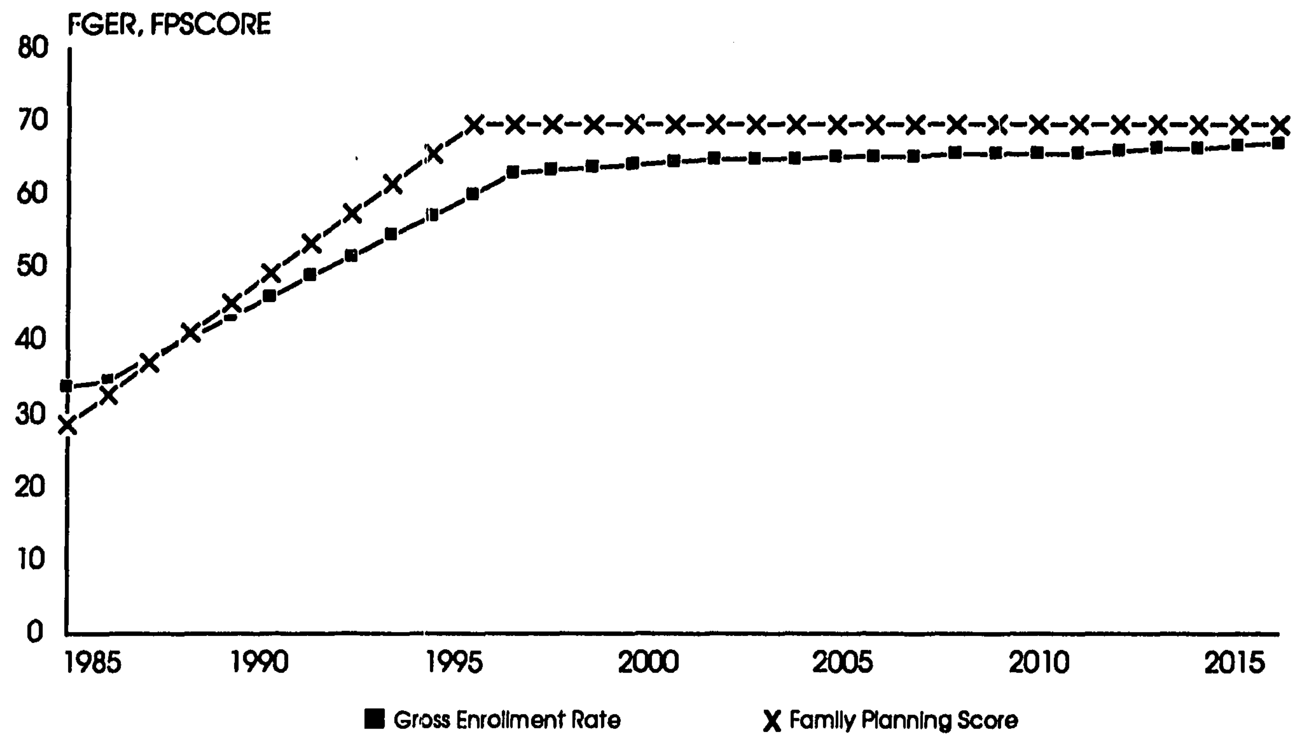
Results on mortality indicators, shown on the bottom of the next page, are similar to those for total fertility rate. Life expectancy trends (not shown) rise from about 51 years to about 60 on trend, and to about 61 with an education program; other factors make little difference. Most of this improvement in life expectancy is due to a decrease in infant mortality. According to trend, infant mortality would drop from about 114 to about 70. But with an education program, a strong downward effect would be felt starting in the year 2005, or perhaps earlier; this decline would be well sustained into the future.

Total Fertility Rate: Pakistan 1985-2015

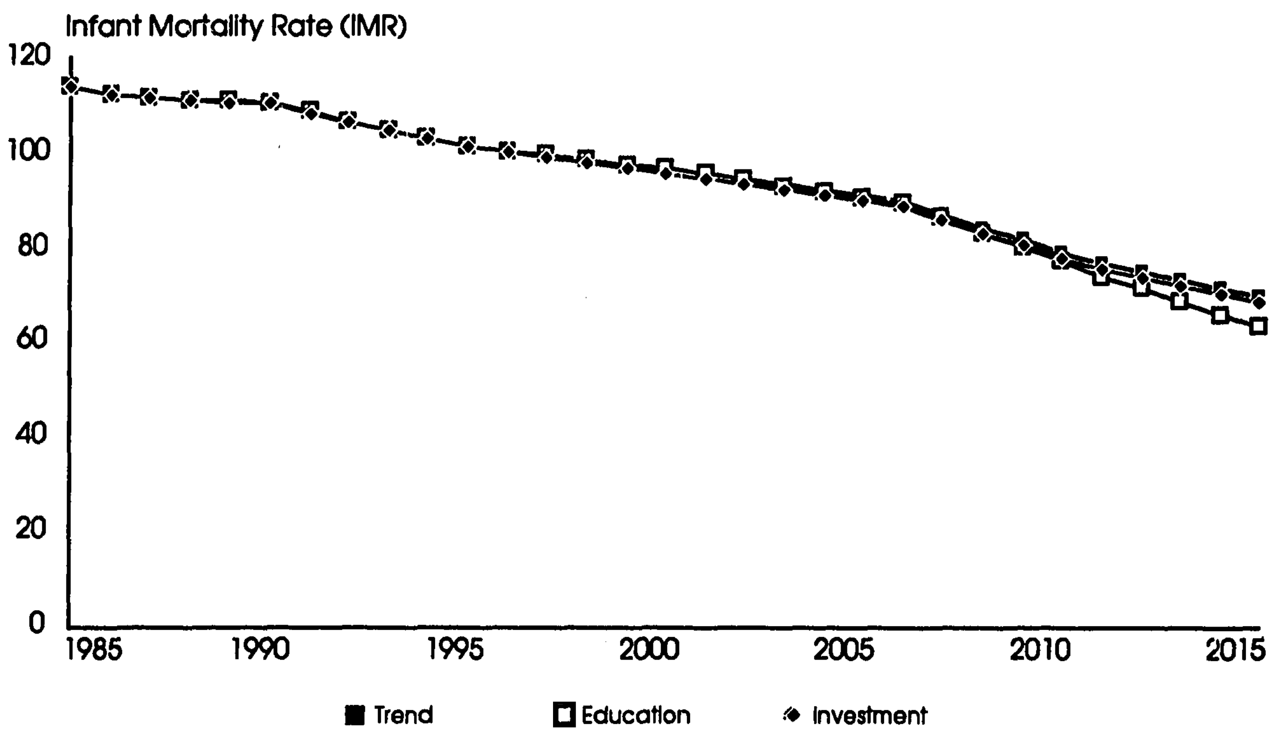


Note: Trend and Investment follow the same path.

Total Fertility Rate Determinants:
Female Gross Enrollment, Family Planning Score



Mortality Indicators: Pakistan 1985-2015

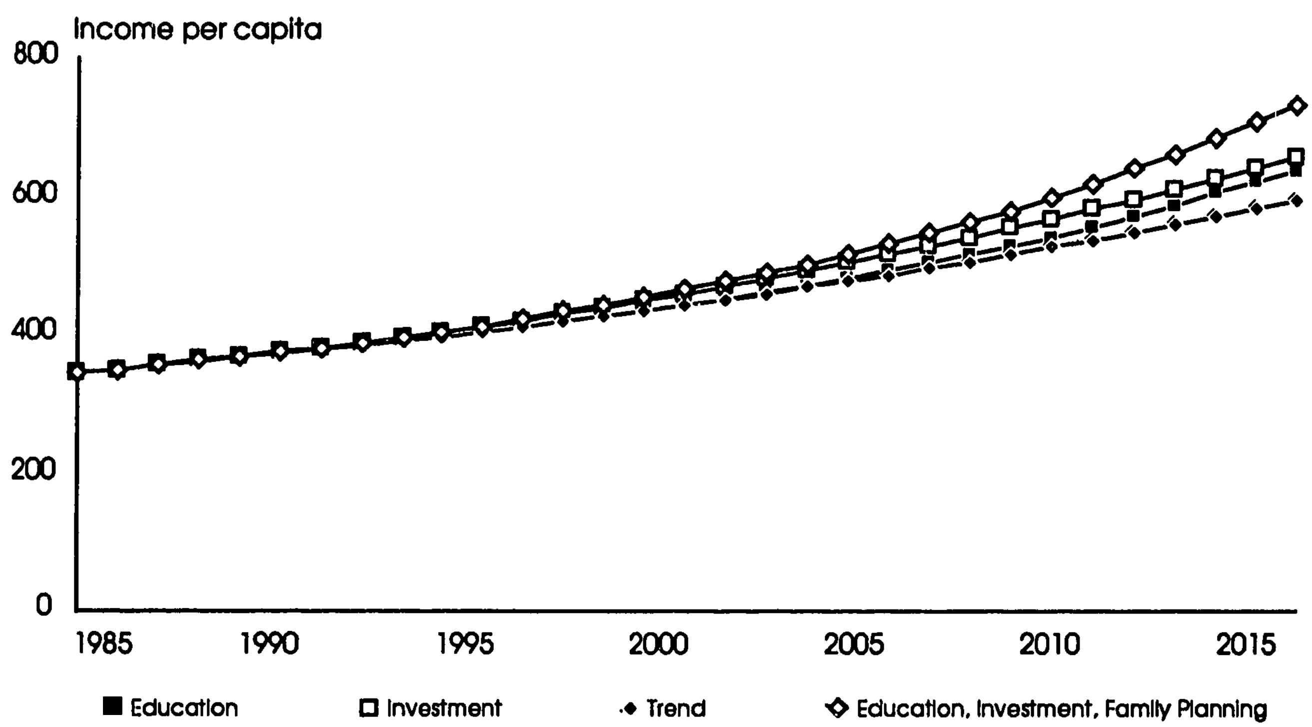


The income trend shows per capita GNP increasing from about US $340 to about $440 by the year 2000 and US $592 by 2015. This is equivalent to about a 1.9% increase in per capita income per year. With more investment, either in education or in traditional forms of investment, income by the year 2015 would increase to $640 or $650, for an annual per capita gain of 2.1%. With a program that emphasizes education, traditional investment, and family planning, income by the year 2015 is US $730, for a yearly per capita increase of 2.6%. None of these numbers should be seen as forecasts. Indeed, a 1.9% forecast of per capita growth could be too cautious for a trend scenario. The important point is that by increasing the share of GDP devoted to education and traditional investment by some 2.7 percentage points, coupled with a strong family planning program, will result in a 20% to 25% higher per capita income. It is the relative magnitude of the rates that matters here, not the projections of absolute levels.

We emphasize the conservative nature of our estimates and of all simulation exercises based on these estimates. Nevertheless, the results of this simulation study confirm the results of rate of return studies: the returns to education are highly competitive with the returns to other forms of investment. In addition, investments in education yield powerful improvements in indicators of well-being such as fertility and infant mortality rates. Given a growth-oriented policy setting, it is likely that the return to all these forms of investment could be considerably higher than we have measured. Our projections should therefore be taken as a very conservative estimate of the likely return to these investments.

In an actual policy presentation in a particular country, all policy parameters, simulation results, and graphs would receive much more discussion. This discussion would center on the logic of the relationships represented in the model and its validity for the country in question. It would also focus on the realistic nature of the target parameters for policy and on practical suggestions for implementing the policies and ideas represented in the model.

Income Growth: Pakistan 1985-2015



References

Adelman, I. "A Linear Programming Model of Educational Planning: A Case Study of Argentina." In I. Adelman & E. Thorbecke, eds., The Theory and Design of Economic Development. Baltimore: Johns Hopkins University Press, 1966.

Barnum & Sabot. "Migration, Education, and Urban Surplus Labor: The Case of Tanzania," Organization for Economic Cooperation and Development, (mimeo), 1976.

Behrman, J.R. "Schooling and Other Human Capital Investments: Can the Effects Be Identified?" *Economics of Education Review*, 6 (3), pp.301-305, 1987.

Benavot, A. "Education, Gender, and Economic Development: A Cross-National Study," *Sociology of Education*, 62(1), pp.14-32, 1989.

Birdsall, N. & Behrman, J.R. "The Quality of Education: Quantity Alone is Misleading (Case Study Brazil)," *American Economic Review...* [Abstracted by LMC], 1983.

Bourdieu, P. & Passeron, J.C. Reproduction in Education, Society, and Culture (trans. R. Nice). London and Beverly Hills: Sage, 1977.

Bowles, S. Planning Educational Systems for Economic Growth. Cambridge, MA: Harvard University Press, 1969.

Caldwell, J.C. Theory of Fertility Decline. New York: Academic Press, 1982.

Caldwell, J.C. "Routes to Low Mortality in Poor Countries," *Population and Development Review*, 12, pp.171-214, 1986.

Caldwell, J.C. & Caldwell, P. "Education and Literacy as Factors in Health." In S.P. Halstead, J.A. Walsh, & K.S. Warre (eds.), Good Health at Low Cost. New York: The Rockefeller Foundation, 1985.

Cochrane, S.H. "Fertility and Education: What Do We Really Know?" (World Bank Staff Occasional Paper No. 26). Washington, DC: The World Bank, 1979.

Cochrane, S.H. "Effects of Education and Urbanization on Fertility." In R. Bulatao & R. Lee (eds.), Determinants of Fertility in Developing Countries, Vol. 2. New York: Academic Press, 1983.

Cochrane, S.H., Leslie, J., & O'Hara, D.J. "Parental Education and Child Health: Intracountry Evidence," *Health Policy and Education* 2, pp.213-250, 1982.

Cochrane, S.H., O'Hara, D.J., & Leslie, J. "The Effects of Education on Health," (World Bank Staff Working Papers No. 405). Washington, DC: The World Bank, 1980.

Coombs, P. The World Education Crisis: A View From the Eighties. Cambridge: Cambridge University Press, 1985.

Crouch, L. "A Note on An Inertia-Sensitive Shortcut to Cohort Component Projections." Manuscript submitted for publication, 1991.

Dervis, K., de Melo, J., & Robinson, S. General Equilibrium Models for Development Policy. Cambridge: Cambridge University Press, 1982.

Dhakal, D., Grabowski, R. & Belbase, K. "The Effect of Education in Nepal's Traditional Agriculture," *Economics of Education Review*, 6(1), pp.27-34, 1987.

Dore, R. The Diploma Disease: Education, Qualification, and Development. Berkeley and Los Angeles: University of California Press, 1976.

D'Souza, S. & Bhuiya, A. "Socioeconomic Mortality Differentials in Rural Bangladesh," *Population and Development Review*, 8(4), pp.753-768, 1982.

Eisemon, T.O. "The Consequences of Schooling: A Review of Research on the Outcomes of Primary Schooling in Developing Countries," (BRIDGES Educational Development Discussion Papers No. 3). Cambridge, MA: Harvard Institute for International Development, 1988.

Freire, P. Pedagogy of the Oppressed (trans. M.B. Ramos). New York: Continuum, 1970/1985.

Freire, P. & Macedo, D. Literacy: Reading the Word and the World. South Hadley, MA: Bergin and Garvey, 1987.

Fuller, B. "What School Factors Raise Achievement in the Third World?" *Review of Educational Research*, 57(3), pp.255-292, 1987.

Gomes, M. "Family Size and Educational Attainment in Kenya," *Population and Development Review*, 10(4), 1984.

Hagen, E. & Hawrylyshyn, 0. "Analysis of World Income and Growth, 1955-65," *Economic Development and Cultural Change*, 18 (1), Part 2, 1969.

Heyneman, S.P. "Uses of Examinations in Developing Countries: Selection, Research, and Education Sector Management," *International Journal of Educational Development*, 7(4) pp.251-263, 1987.

Heyneman, S.P. & White, D.S., eds. The Quality of Education and Economic Development. Washington, DC: The World Bank, 1986.

Hicks, N. "Economic Growth and Human Resources," (World Bank Staff Working Paper No. 408). Washington, DC: The World Bank, 1980.

Hobcraft, J.N., McDonald, J.W., & Rutstein, S.O. "Socioeconomic Factors in Infant and Child Mortality: A Cross-Country Comparison," *Population Studies*, 38, pp.193-223, 1984.

Horton, S. & King, T. "Labor Productivity: Un Tour d'Horizon," (World Bank Staff Working Paper No. 497). Washington, DC: The World Bank, 1981.

International Labour Office (ILO). Yearbook of Labour Statistics 1985. Geneva: ILO, 1985

International Labour Office (ILO). Yearbook of Labour Statistics 1987. Geneva: ILO, 1987.

International Labour Office (ILO). Yearbook of Labour Statistics 1988. Geneva: ILO, 1988.

Jamison, D.T. & Moock, P.R. "Farmer Education and Farm Efficiency in Nepal: The Role of Schooling, Extension Services and Cognitive Skills," *World Development*, 12, pp.67-86, 1984.

Kasarda, J.D., Billy, J.O., & West, K. Status Enhancement and Fertility: Reproductive Responses to Social Mobility and Educational Opportunity. New York: Academic Press, 1986, [cited in LeVine, 1987].

Kelly, G.P. "Comparative Education and the Problem of Change: An Agenda for the 1980s," *Comparative Education Review*, 31(4) pp.477-489, 1987.

Komenan, A.G. World Education Indicators: An Annex to "Improving the Efficiency of Education in Developing Countries", (Education and Training Series Report No. EDT 88). Washington, DC: The World Bank, 1987.

LeVine, R.A. "Women's Schooling, Patterns of Fertility, and Child Survival," *Educational Researcher*, 16, pp.21-27, 1987.

Lockheed, M.E., Jamison, D.T., & Lau, L.J. "Farmer Education and Farm Efficiency," *Economic Development and Cultural Change*, 29, pp.37-76, 1980.

Lockheed, M.E., Verspoor, A., et al. Improving Primary Education in Developing Countries: A Review of Policy Options. Washington, DC: The World Bank, 1989.

McMahon. "The Relation of Education and R & D to Productivity Growth in the Developing Countries of Africa." *Economics of Education Review* [Abstracted by LMC], 1987.

Moreland, R.S. "Population, Internal Migration, and Economic Growth: An Empirical Analysis," Research in Population Economics, 4, pp.173-216, 1982.

Moreland, R.S. Population, Development, and Income Distribution - A Modelling Approach. New York: St. Martin's Press, 1984.

Ogbu, O. & Gallagher, M. "On Public Expenditures and Delivery of Education in subSaharan Africa," *Comparative Education Review*, 35(2), pp.295-318, 1991.

O'Hara, D. J. "Toward a Model of the Effects of Education and Health." In S.H. Cochrane, D.J. O'Hara, & J. Leslie, The Effects of Education on Health (World Bank Staff Working Papers No. 405, pp.34-55). Washington, DC: The World Bank, 1980.

Phillips, J.M. & Marble, R.P. "Farmer Education and Efficiency: A Frontier Production Function Approach," *Economics of Education Review*, 5(3) pp.257-264, 1986.

Population Crisis Committee. Access to Birth Control: A World Assessment (Briefing Paper No. 19). Washington, DC: Population Crisis Committee, 1987.

Psacharopoulos, G. "The Contribution of Education to Economic Growth: International Comparisons." In J.W. Kendrick (ed.), International Comparisons of Productivity and Causes of the Slowdown, pp.335-355. Cambridge, MA: Ballinger Publishing Company, 1984.

Psacharopoulos, G. & Woodhall, M. Education for Development: An Analysis of Investment Choices. New York: Oxford University Press, 1985.

Ram, R. "Exports and Economic Growth in Developing Countries: Evidence from Time-Series and Cross-Section Data," *Economic Development and Cultural Change*, 36(1), pp.51-63, 1987.

Ram, R. "Can Educational Expansion Reduce Income Inequality in Less-Developed Countries?" *Economics of Education Review*, 8(2), pp.185-195, 1989.

Reimers, F. "The Impact of Economic Stabilization and Adjustment on Education in Latin America," *Comparative Education Review*, 35 (2), pp.319-353, 1991.

Robinson, S. "Sources of Growth in Less Developed Countries: A Cross-Section Study," *Quarterly Journal of Economics*, 85(3), pp.391-408, 1971.

Schultz, T.P. "School Expenditures and Enrollments, 1960-1980: The Effect of Income, Prices, and Population Growth." In D.G. Johnson & R.D. Lee (eds.), Population Growth and Economic Development: Issues and Evidence, pp.413-476. Madison, WI: University of Wisconsin Press, 1987.

Simmons, J. "The Determinants of Earnings: Towards an Improved Model," (World Bank Staff Working Paper No. 173). Washington, DC: The World Bank, 1974.

Simmons, J. "Education for Development, Reconsidered," *World Development*, 7, pp.1005-1016, 1979.

Smock, A.C. Women's Education in Developing Countries: Opportunities and Outcomes. New York: Praeger, 1981.

Tan, J.P. & Haines, M. "Schooling and Demand for Children: Historical Perspectives," (World Bank Staff Working Papers No. 697). Washington, DC: The World Bank, 1984.

Unesco. Statistical Yearbook, Paris: Unesco, 1986.

United Nations. Fertility Behavior in the Context of Development: Evidence from the World Fertility Survey. New York: United Nations, 1987.

Walker, D.A. The IEA Six Subject Survey: An Empirical Study of Education in Twenty-One Countries. Stockholm: Almqvist & Wiksell International, 1976.

Wheeler, D. "Human Resource Development and Economic Growth in Developing Countries: A Simultaneous Model," (World Bank Staff Working Paper No. 407). Washington, DC: The World Bank, 1980.

Wheeler, D. Human Resource Policies, Economic Growth, and Demographic Change in Developing Countries. Oxford: Clarendon Press, 1984a.

Wheeler, D. "Female Education, Family Planning, Income, and Population: A Long-Run Econometric Simulation Model," Background paper for the World Bank Development Report (manuscript), 1984b.

World Bank. World Tables 1984. Washington, DC: The World Bank, 1984.

World Bank. Education in subSaharan Africa: Policies for Adjustment, Revitalization, and Expansion. Washington, DC: The World Bank, 1988a.

World Bank. "World Development Indicators." In World Development Report 1988, pp.211-305. Washington, DC: The World Bank, 1988b.

World Bank. World Tables: 1988-1989 Edition. Washington, DC: The World Bank, 1989.

World Bank. World Development Report 1991. New York: Oxford University Press, 1991.

Appendix 1: Countries in the EIM database with selected 1985 data values*

COUNTRY	POP	GNPPC	GER1F	GER1M	GER2F	GER2M	TFR	IMR	LEXP
Algeria	21718	2550	82	104	43	59	6.2	72	61
Argentina	30564	2120	108	106	75	66	3.2	30	70
Bangladesh	101000	150	50	70	10	36	5.7	125	50
Benin	4043	260	43	87	12	29	6.5	112	49
Bhutan	1287	120	19	35	1	6	5.8	139	45
Bolivia	6378	490	83	95	34	40	6.1	119	53
Botswana	1070	870	113	103	31	27	6.7	72	58
Brazil	136000	1670	97	105	.	.	3.6	57	65
Burkina Faso	7881	150	21	37	3	7	6.5	132	47
Burundi	4696	240	44	62	3	5	6.5	117	48
Cameroon	10191	840	98	118	18	29	6.8	90	55
Central African Rep	2583	280	59	95	.	.	5.6	122	49
Chile	12074	1450	104	108	69	63	2.6	25	71
China	1040000	320	114	134	32	45	2.3	40	69
Colombia	28418	1350	119	115	51	50	3.3	49	65
Congo People's Rep	1884	1070	.	.	.	.	6.3	75	58
Costa Rica	2490	1400	96	98	43	39	3.4	17	73
Cote d'Ivoire	10252	630	57	83	12	27	7.2	99	52
Dominican Rep	6420	760	129	125	57	44	3.9	57	65
Ecuador	9378	1150	112	112	53	51	4.6	55	65
Egypt Arab Rep	48503	640	78	96	52	73	4.7	78	61
El Salvador	4781	830	76	74	26	23	5.0	65	60
Ethiopia	42271	110	27	41	9	14	6.2	137	45
Gabon	997	3330	151	155	20	30	5.1	103	51
Ghana	12737	370	66	86	27	45	6.3	92	53
Greece	9919	3620	104	104	84	87	1.9	12	76
Guatemala	7973	1190	70	84	16	17	5.9	67	60
Haiti	5933	310	89	101	17	19	4.9	119	54
Honduras	4382	740	103	101	36	31	5.8	65	63
India	765000	290	79	111	24	45	4.5	88	56
Indonesia	163000	520	114	122	34	45	4.0	91	56
Jamaica	2311	920	107	105	60	56	3.3	19	73
Jordan	3506	1530	85	85	78	80	6.1	54	65
Kenya	20353	300	96	100	16	25	7.8	82	57
Rep of Korea	41056	2160	97	95	91	97	2.3	32	69
Lesotho	1545	410	125	101	26	18	5.8	94	55
Liberia	2178	480	25	47	.	.	6.6	91	54
Madagascar	10212	240	109	117	30	43	6.4	118	53
Malawi	7141	170	53	71	2	6	7.6	164	45
Malaysia	15676	1970	100	100	53	52	3.6	33	69
Mali	7389	150	16	28	4	10	6.5	144	46
Mauritania	1764	410	39	59	.	.	6.5	126	46

APPENDIX 1 (Cont.)

COUNTRY	POP	GNPPC	GER1F	GER1M	GER2F	GER2M	TFR	IMR	LEXP
Mauritius	1020	1100	106	104	49	53	2.3	42	66
Mexico	78524	2200	118	120	54	56	3.8	42	68
Morocco	21941	560	61	95	25	38	4.6	94	60
Mozambique	13791	180	75	97	4	9	6.3	122	47
Myanmar	.	.	100	110	.	.	4.6	70	58
Nepal	16625	170	50	114	11	35	6.0	136	47
Nicaragua	3276	770	107	97	55	23	5.7	69	61
Niger	6391	240	20	36	3	9	7.0	139	44
Nigeria	99669	950	68	86	.	.	6.9	107	50
Oman	1242	7510	80	98	21	43	6.9	115	54
Pakistan	96180	340	34	62	9	24	6.8	114	51
Panama	2180	2100	103	107	63	56	3.3	24	72
Papua New Guinea	3329	710	59	69	.	.	5.3	79	52
Paraguay	3696	1190	100	106	30	31	4.7	43	67
Peru	19383	1010	120	124	61	68	4.2	80	60
Philippines	55810	570	107	105	66	63	4.6	53	63
Rwanda	6026	280	61	65	2	3	8.0	118	48
Senegal	6567	370	45	65	9	18	6.6	128	47
Sierra Leone	3657	350	43	63	.	.	6.5	169	40
Somalia	5384	270	13	27	12	23	6.8	130	46
South Africa	31593	2080	83	83	.	.	4.6	72	60
Sri Lanka	15837	380	102	104	67	60	3.0	29	70
Sudan	21931	280	41	59	17	22	6.6	114	49
Syrian Arab Rep	10458	1610	101	115	49	72	7.0	54	64
Tanzania	22242	300	71	73	2	4	7.0	102	52
Thailand	51683	810	94	98	.	.	3.1	51	64
Togo	3038	230	73	117	10	33	6.5	97	52
Trinidad	1185	6180	96	94	79	74	3.0	28	69
Tunisia	7143	1190	106	126	33	46	4.5	67	63
Turkey	50310	1080	110	116	28	47	3.8	66	64
Uganda	14680	230	55	75	.	.	6.9	115	47
Uruguay	2970	1730	109	111	.	.	2.7	28	71
Venezuela	17317	3800	108	110	50	41	3.9	33	70
Yemen Arab Rep	7955	670	33	131	3	17	6.8	153	45
Yemen PDR	2137	490	37	103	11	26	6.6	138	49
Zaire	30712	160	82	106	33	81	6.1	101	52
Zambia	6704	410	95	117	14	24	6.8	91	52
Zimbabwe	8406	640	131	139	35	51	6.2	75	57

*Note abbreviations as follows:

POP = Total population (in 1000's)
GNPPC = Gross national product per capita (Atlas method)
GER1F = Gross primary enrollment rate, females
GER1M = Gross primary enrollment rate, males
GER2F = Gross secondary enrollment rate, females
GER2M = Gross secondary enrollment rate, males
TFR = Total fertility rate (births per woman)
IMR = Infant mortality rate (deaths per 1000 births)
LEXP = Life expectancy (years)

Appendix 2: Variables in the EIM database

1. Education policy variables[a]

EDSH	Education budget as share of GNP (1975 - 1985)
PEXP	Proportion of EDSH to primary education (1975 - 1985)
TSALRT	Teacher salary as multiple of GNP per capita (circa 1982)
STRP	Primary school student-teacher ratio (1965 - 1985)
XPSP	Expenditures per student as proportion of GNP per capita (1975 - 1985)

2. Educational participation variables[a]

GER1F	Gross female primary enrollment rate (1960 - 1985)
GER1M	Gross male primary enrollment rate (1960 - 1985)
GER1T	Gross total primary enrollment rate (1960 - 1985)
PEDCF	Grade 5 completion rate, females (1975, 1980)
PEDCM	Grade 5 completion rate, males (1975, 1980)
GER2F	Gross female secondary enrollment rate (1960 - 1985)
GER2M	Gross male secondary enrollment rate (1960 - 1985)
GER2T	Gross total secondary enrollment rate (1960 - 1985)
DIND1	Gender disparity index for primary education (computed) (GER1M - GER1F) / (GER1M + GER1F)
DIND2	Gender disparity index for secondary education (computed) (GER2M - GER2F) / (GER2M + GER2F)

3. Demographic variables[b]

TFR	Total fertility rate (births per woman) (1960 - 1985)
IMR	Infant mortality rate (deaths/1000 births) (1960 - 1985)
LEXP	Life expectancy (years) (1960 - 1985)
CBR	Crude birth rate (1960 - 1985)
CDR	Crude death rate (1960 - 1985)
POP	Population (1960 - 1985)
POPGR	Average annual population growth rate (computed)

4. Labor force variables[c]

LFPRF	Female labor force participation rate (1960 - 1985)
LFPRM	Male labor force participation rate (1960 - 1985)
LAGRI	Proportion of the labor force in agriculture (1960 - 1985)
LABOR	Total labor force (1960 - 1985; computed)
LABGR	Average annual labor force growth rate (computed)
AGEMARR	Female age at marriage (mid-1970s)

5. Economic Productivity variables[d]

PROD	Labor productivity in constant 1985 US$ (1960 - 1985)
GNP	Gross national product in constant 1985 US$ (1960 - 1985)
GNPPC	Gross national product per capita (1960 - 1985)
GNPGR	Rate of annual GNP growth from 1965 to 1985

6. Control variables[e]

FPSCORE	Level of support for family planning (mid-1970s)
INSHAV	Share of GNP invested (1960 - 1985)
AVGTT	Average annual change in terms of trade from 1965 to 1985
AFRICA	Dummy variables grouping subSaharan African countries
ASIA	Asian countries east of Pakistan
MENA	Middle East and North African countries
LAC	Latin American and Caribbean countries

a. The principal source of primary education data (1965-1985) was Lockheed, Verspoor, et al., (1989); 1960 primary-level data and 1960-1980 secondary data were drawn from the 1984 World Tables database (World Bank, 1984); 1985 secondary data from 1988-1989 World Tables database (World Bank, 1989). Additional sources were consulted in the following order to supply missing values where possible: World Bank (1988a); World Bank (1988b); Komenan (1987).

b. The 1984 World Tables database (World Bank, 1984) was the source for all variables listed through 1980; 1985 data were drawn from the 1988-1989 World Tables database (World Bank, 1989). Additional sources were consulted in the following order to supply missing values where possible: World Bank (1988b); World Bank (1988a).

c. The 1984 World Tables database (World Bank, 1984) was the source for all labor force variables listed through 1980; 1985 data were drawn from Yearbooks of Labor Statistics (ILO, 1985, 1987, 1988). Additional sources were consulted in the following order to supply missing values where possible: World Bank (1988b); World Bank (1988a). AGEMARR was obtained from United Nations (1987).

d. The 1984 World Tables database (World Bank, 1984) was the source for PROD, GNP, and GNPPC values through 1980; 1985 data were drawn from the 1988-1989 World Tables database (World Bank, 1989). Additional sources were consulted in the following order to supply missing values where possible: World Bank (1988b); World Bank (1988a). GNPGR (as proxied by GDP growth) was obtained from World Bank (1988b).

e. INSHAV was drawn from 1984 (for 1960-1980 data) and 1988-1989 (for 1985 figures) World Tables databases (World Bank, 1984; 1989); FPSCORE was developed by the Population Crisis Committee (1987).

Appendix 3: Final EIM estimation equations

1. Educational participation equations

(1985 models, n = 44):

GER1F(t) = 119.943 – 0.362*LAGRI(t–5) + 1858.146*EDSH*PEXP(t) - 324.854*XPSP(t)
(R^2 = .686) (15.08) (3.03) (5.50) (8.06)

GER1M(t) = 119.325 – 0.205*LAGRI(t–5) + 1600.117*EDSH*PEXP(t) – 291.565*XPSP(t)
(R^2 = .715) (19.05) (2.18) (6.02) (9.19)

(1980 models; F, n = 49; M, n = 50):

PEDCF(t) = –24.582 + 0.165*GERF(t–5) + 19.906*ln(XPSP*GNPPC(t)) – 27.515*LAC
(R^2=.664) (2.50) (2.31) (8.28) (5.58)

PEDCM(t) = 18.084 + 21.287*ln(XPSP*GNPPC(t)) – 27.800*LAC
(R^2=.645) (1.79) (8.97) (6.17)

(1985 models; n = 52):

GER2F = 42.894 + .00328*GERF(t–5)*PEDCF(t–5) + 15.355*ASIA + 8.511*LAC – .566*LAGRI(t–5)
(R^2=.798) (5.02) (5.27) (2.83) (1.95) (5.73)

GER2M = 54.526 + .00253*GERM(t–5)*PEDCM(t–5) + 19.094*ASIA – .594*LAGRI(t–5)
(R^2=.665) (6.24) (3.48) (2.97) (6.15)

GER(i,t) = (GER(i,f,t) + GER(i,m,t)) / 2

DIND(i,t) = (GER(i,m,t) – GER(i,f,t)) / (GER(i,m,t) + GER(i,f,t)

2. Population equations

(1985 model; N=44):

TFR =6.128 – 0.00035*[GER1F(t–20) + GER2F(t–20)]*FPSCORE + 0.62*AFRICA
(R^2=.787) (29) (9.8) (2.8)

(1985 model; N = 77):

ln(IMR) = 5.863 – 0.00221*GERF(t–20) – 0.0289*GER2F(t–20) + 0.173* ln(GNPPC)
(R^2=0.839) (24.08) (1.55) (8.55) (3.87)

(1985 model, N = 78):

LEXP = 73.528 – .185*IMR(t) + .073*GER2T(t-20) – 2.932*AFRICA – 2.464*ASIA
(R^2=.973) (83.19) (26.24) (3.23) (6.45) (4.88)

(1980 and 1985 data pooled, N = 160):

CBR(t) = 1.3758 + 0.4579*CBR(t–5) + 3.58*TFR(t)
(R^2=.959) (1.7) (8.3) (10.8)

(1980 and 1985 data pooled, N = 151):

CDR(t) = –10.0904 + 0.4518*CDR(t–5) + 910.6913/LEXP(t)
(R^2=.977) (–11.4) (10.8) (11.4)

POP(t) = POP(t–1) * (1 + CBR(t)/1000 – CDR(t)/1000)

3. Labor force equations

AGEMARR = 4.652 + 3.784 * ln(PEDCF(t)) – 1.770 * AFRICA + 2.549 * ASIA + 1.633*LAC
(R^2=.567) (1.22) (4.22) (2.09) (2.57) (1.92)

LFPRF(t) = exp(–4.897) * pwr(AGEMARR, 2.630) * exp(0.829*AFRICA) * exp(–0.846*MENA)
(R^2=.516) (1.67) (2.75) (3.66) (2.91)

LAGRI(t) = 150.399 - 14.350 * ln(GNPPC(t–10) – 8.861 * ln(GER2T(t–20)
(R^2=.736) (14.00) (6.11) (5.50)

* LFPR(t) = (LFPR(f,t) + LFPR(m,t)) / 2

* LABOR(t) = POP(t) * LFPR(t) /100

4. Economic productivity equations

GNPGR(t)= 0.603 + 0.139*INSHAV + 0.00898*GER1T(t–10)*LABGR
(R^2=.254) (0.7) (3.6) (3.0)

GNP(t) = GNP(t–1) + (1+GNPGR/100)

GNPPC(t) = GNP(t) / POP(t)

BRIDGES Publications Staff:

Billie Jo Joy, Publications Coordinator
Pamela Summa, Editorial Assistant
Brenda Salyer, Graphic Designer
Proofreaders: Claire Chafee-Bahamon and Christine Terr

For more information about this or other BRIDGES documents, please contact:

BRIDGES Publications
One Eliot Street
Harvard University
Cambridge, MA 02138
USA
(617) 495-9786

or

USAID
Office of Education
Bureau for Science and Technology
Department of State
Washington, D.C. 20523
(703) 235-8980

79